המועצה המדעית לישראל

C.N.R.S.-B.N.F.C.
T 05
R 24 NOV 1952
A
D 5.12.52.
Ab. articles: pp.
nil

BULLETIN
OF THE
RESEARCH COUNCIL OF ISRAEL

VOLUME II SEPTEMBER 1952 NUMBER 2

JERUSALEM

BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL

EDITORIAL BOARD

S. SAMBURSKY, *Chairman*

S. ADLER
E. D. BERGMANN
F. S. BODENHEIMER
M. EVEN ARI
L. PICARD
G. RACAH
M. REINER

M. BALABAN, *Executive Editor*

NOTICE TO CONTRIBUTORS

Contributors to the *Bulletin of the Research Council of Israel* are requested to cooperate by conforming to the following recommendations of the editors of this journal in preparing manuscripts for the press.

Contributions must be original and should not have been published previously. When a paper has been accepted for publication, the author(s) may not publish elsewhere unless permission is received from the Editor of this journal.

Papers may be submitted in the following languages: English, French and Russian.

MANUSCRIPT

General

Papers should be written as concisely as possible. MSS should be typewritten, on one side only, and double-spaced with side margins not less than 2.5 cm wide. Pages, including those containing illustrations should be numbered.

The Editor reserves the right to return a MS to the author for retyping or any alterations. Authors should retain copies of their MS.

Spelling

Spelling should be based on the Oxford Dictionary and should be consistent throughout the paper. Particularly geographic and proper names should be checked for approved forms of spelling or transliteration.

Indications

Italics

All symbols and text to be italicized should be underlined.

Capitals

Capital letters should be capitalized in the MS.

Stopping

Words to be stopped should be s p a c e d out in the MS.

Other specifications

Any other variations in type size or character should be indicated clearly in a legend preceding the MS.

Mathematical script

Special care should be taken to record clearly relative height of symbols to the line. This is often more easily achieved in legible handwriting rather than typing. Indices and subscripts should be accurately placed. As far as possible formulae should be confined to one line, e.g. $\frac{1}{x}$ should rather be written $1/x$.

Greek letters should be indicated in a legend preceding the MS as well as by a pencil note in the margin, upon first appearance in the text.

There should be distinct differentiation between the letter "l" and the figure "1" in the text; also between "O" and "0".

Mathematical Punctuation

Decimal division is indicated by use of a full stop on the line, e.g., 1.000 (one, accurate to the thousandth place). Division of thousands is made by use of a comma, e.g., 1,000 (one thousand). Multiplication is indicated by a full stop centrally placed, e.g. $8{\cdot}10^{12}$.

Abbreviations

Titles of journals should be abbreviated according to the *World List of Scientific Periodicals*.

Units are used in the abbreviated form, in the singular, and are not followed by a full stop (only in. is followed by a full stop). The following is a list of the more common symbols: mm cm m km cm^2 m^2 μg mg g kg sec min hr °K °C

Summary

Every paper must be accompanied by a brief but comprehensive summary. Although the length of the summary is left to the discretion of the author, 5% of the total length of the paper is suggested.

(cont'd on inside back cover)

המועצה המדעית לישראל

BULLETIN
OF THE
RESEARCH COUNCIL OF ISRAEL

VOLUME II SEPTEMBER 1952 NUMBER 2

JERUSALEM

ד. מ. ירם 294/9,52/1000

C. B.
Rec'd 24 1952
Ab.
Date
Ab. articles: pp.

המועצה המדעית לישראל

BULLETIN
OF THE
RESEARCH COUNCIL OF ISRAEL

SUPPLEMENT

SOME ANATOMICAL FEATURES OF THE INDIGENOUS WOODY VEGETATION OF ISRAEL

I. GINDEL

VOLUME II SEPTEMBER 1952 NUMBER 2

JERUSALEM

SOME ANATOMICAL FEATURES OF THE INDIGENOUS WOODY VEGETATION OF ISRAEL

I. GINDEL
Forest Research Laboratory, Rehovot

Although Israel constitutes the southeastern perimeter of the Mediterranean macqui, only part of the country is covered by this woodland vegetation. Areas with annual precipitation below 350 mm are occupied by semi-desert and desert plants which are also characteristic of the arid zone of Africa, such as species of *Suaeda*, *Atriplex* and *Tamarix*, *Retama Roetam*, *Acacia Raddiana*, *A. spirocarpa*, etc.

There was very little previous information on the anatomy of the indigenous woody vegetation of this country, when the present investigation was undertaken. Since the underlying aim was to relate anatomical features to the environment, only the indigenous vegetation was studied, to the exclusion of acclimatized species. Many of the plants discussed in this paper are of silvicultural importance; however, in order to obtain a complete picture, fruticose and suffruticose species of frequent occurrence in the natural vegetation, were also included.

REVIEW OF LITERATURE

As long ago as 1883, Radlkofer[9] emphasized the importance of anatomy in defining species. Many data based on the work of other anatomists were included by Radlkofer's pupil Solereder[12] in his book on the systematic anatomy of wood vegetation.

A correlation between morphology and wood structure was first attempted by Simon[11]. He concludes from his analysis of European and Mediterranean "summergreens" and "wintergreeens" that the latter are distinguished by a more homogenous distribution of pores and mechanical tissues. In the summergreen species the parenchymatous tissue is better developed, whereas fibrous tissue is preponderant in the evergreens.

According to Bews, the evergreens represent a relatively low evolutionary level among the angiosperms, while the deciduous species have developed from primitive evergreens. The structure of evergreens is adapted to low water conductivity.

Huber[4] draws the following conclusions from his study of wintergreen and summergreen species of Central Europe: 1. A correlation exists between the ring-porous structure and the rate of formation of coloured heart-wood which takes no part in the physiological life of the tree. 2. The rate of sap flow in ring-porous wood exceeds ten times that prevailing in diffuse-porous wood. 3. The ring-porous species are mostly xerophylous and light-lovers, in contrast to diffuse-porous species which are mostly shade-tolerant (e.g. *Fagus*, *Tilia*, *Acer*, *Aesculus*).

Weber[13] states that the sclerophilous and desert species have narrow rings of the diffuse-porous type. This phenomenon is related to the reduction of late wood, due

to premature interruption of cambium activity under the adverse climatic conditions. Some of the diffuse-porous species are capable of becoming ring-porous in a more favourable environment. The short growth period in the desert precludes any pronounced differentation between the early and late wood. Webber defines the anatomical features of the xerophilous shrubs of California as follows: (a) wood predominantly diffuse-porous with mostly simple perforations, (b) spiral thickenings on the lateral walls, (c) pores of small diameter.

Messeri[7] suggests a correlation between the wood structure in plants of the Sahara Desert and the ecological conditions under which they have evolved. She draws the following conclusions: 1. All the species examined can be classified in four groups according to their wood structure. 2. Evergreens are poorly represented in the desert and those which occur are predominantly of Mediterranean or Sudanese origin. The aphyllous and aloid evergreens and ring-porous wood structure constitute the principal adaptations to desert conditions.

In Israel, anatomical studies from a physiological point of view were conducted by by Evenari[3] who found a correlation between the area occupied by vascular bundles in the cross-section of the stem, the leaf structure, and the transpiration of some desert species. The rate of transpiration increases in proportion to the area covered by the vascular elements, except in *Atriplex*, where the relationship is reversed. Oppenheimer[8] has described the progress of cambium activity in the Aleppo pine.

WORKING PROCEDURE

Specimens of dominant species were selected from sparse populations so that no incidental factors, such as overcrowding, should disturb the influence of climatic and edaphic conditions. There are indications that high density of vegetation seriously interferes with the formation of annual rings, thus obscuring the difference between the diffuse-porous and ring-porous types, which is of fundamental importance in connection with our study. To avoid any similar derangement in the normal progress of cell formation by such factors as attack by fungi or insects, exceptional dryness, etc., samples were collected only from healthy and well developed plants. Since conspicuous differences in the arrangement and size of the wood elements had been noted in sections derived from different parts of the plant, all samples were taken from the main stem.

Three wooden cubes from each species, about 8 mm in size, after boiling in water for 2—3 hours, were kept in wax receptacles containing hydro-fluoric acid for a period of 2—6 months. The cubes were subsequently washed in running water, boiled again to remove all traces of the acid and than immersed for 4—8 weeks in a mixture consisting of 3 parts of glycerin to 1 part of alcohol (96%). This treatment failed to overcome sectioning difficulties in some plants, such as species of *Pistacia*, *Quercus*, *Salsola* and *Salvadora*, samples of which crumbled under the knife. To facilitate cutting, the wood samples were immersed into blocks of paraffin. The slicing microtome was found suitable for sectioning tough xerophytic woods.

Numerous transverse, radial and tangential sections were made to provide sufficient material for the measurements and computations presented in this study.

No uniform dying technique could be employed and suitable adaptions of method

had to be made for certain groups of plants. The following procedure gave good results with most species:

1. Immersion in a 10% solution of chromo-acetic acid (equal parts of both constituents) for a peroid of 30 to 48 hours.
2. Immersion in methyl-green for 6 to 12 hours, depending on the species.
3. Washing for 1 hour in water.
4. Immersion in fuchsin for 6 to 12 minutes.
5. Dehydration and mounting in balsam in the usual way.

Hematoxylin (Heidenheim) combined with safranin was also used with good results on *Chenopodiaceae* and a few genera belonging to other families.

The following features were selected for the comparison of anatomical structure between the different species: (1) arrangement of pores as seen in cross-section, (2) distribution of pores within the annual ring, e.g. diffuse-porous or ring-porous, (3) the tangential diameter of the pores, (4) type of vessel perforation, (5) arrangement of xylem parenchyma, (6) arrangement of wood rays, (7) width of rays, (8) height of rays, (9) number of rays per 5mm as counted in tangential direction in the cross-section, (10) presence of crystals.

About fifty measurements of pores and rays were taken for each species.

NOMENCLATURE

The definition of the wood structure of different species was largely based on the important work accomplished by the Nomenclature Committee of the International Association of Wood Anatomists[5,6] in standardizing the nomenclature of the various wood elements.

The Committee on Nomenclature of the I.A.W.A.[5] distinguishes the following pore arrangements: (a) solitary pore, (b) pore multiple, (c) pore chain, (d) pore cluster. It has been necessary in some instances to fall back on additional definitions introduced by the Princes Risborough Laboratory, such as "exclusively solitary" and "radial or oblique arrangement". Some of Record's[10] terms regarding pore arrangement were found appropriate as, for instance, "frame-like" or "dendritic" arrangement in the case of *Rhamnus* and some other genera, and "orbicular" or "angular" for the delineation of lumen.

According to the I.A.W.A. definitions[5], a species is diffuse-porous — when the pores are of fairly uniform, only gradually changing in size and are uniformy distributed throughout the growth ring; ring-porous—when the pores of one part of the growth ring are in distinct contrast in size or number (or both) to those of the other part; intermediate — when there is a gradual diminution in the size of the pores, but the differences between the early and late wood are too conspicuous to allow for inclusion in the diffuse-porous group.

In differentiating between various types of parenchyma, the following designations were employed: (a) diffuse, (b) metatracheal, (c) terminal, (d) paratracheal (a combination of diffuse and metatracheal parenchyma), (e) reticulate (fine threads of parenchyma alternating with vascular rays in a net-like pattern).

DISCUSSION

With regard to pore distribution, the indigenous woody vegetation of Israel can be divided into three categories: (a) diffuse-porous, (b) ring-porous and (3) intermediate. 83.5 per cent of the examined evergreens are diffuse-porous, 14 per cent intermediate, and only 2.5 per cent ring-porous. On the other hand, the percentage ratio for deciduous species is 26.3, 31.5 and 42, respectively. The evergreens which constitute the major part of the natural woody flora of this country, are thus predominanrly of the diffuse-porous type. These relationships have been shown to have a much wider application. A general survey of the arborescent vegetation of the tropics and subtropics also indicated the preponderance of diffuse porosity among the evergreens of these regions, as opposed to deciduous plants whose structure is mostly ring-porous. The intermediate type is to be found in both evergreen and deciduous species. The diffuse-porous structure prevails in broom-like plants, such as *Calycotome villosa*, *Spartium junceum* and *Retama Roetam* which lose their minute leaves but retain the green shoots during the dry season.

Simple perforations appear to be characteristic of xeromorphous vegetation. This observation is in agreement with Webber's[13] conclusion, but contradicts the findings of Bews[1] and Huber[4], who claim that scalariform perforation is dominant in such plants. The apparent disagreement may be put down to the fact that the results of these workers refer to xerophilous species growing in a mesophytic environment, whereas our conclusions, as well as those of Webber, are based on plants actually growing under semi-arid or even arid conditions.

The diffuse-porous species discussed in this study do not possess the isometric wood strucrute common in the vegetation of the tropics, where there are no great changes in the climate throughout the greater part of the year. The subtropical climate prevailing in Israel is characterized by a hot rainless season which lasts for six to seven month and cool rainy weather during the rest of the year. This periodicity finds its expression in all the three categories of porosity. The resumption of cambium activity, after a period of rest which is somewhat longer in deciduous species than in evergreens, is marked by larger pores and an abundance of other wood elements. The difference between the early and late wood, though relatively slight in the diffuse-porous plants, is rather conspicuous in species endowed with ring-porous strucrute.

The influence of seasonal climatic changes on the structure of the annual rings have been observed in some of our desert plants. *Acacia Raddiana* for instance, forms at the end of the growing season a thick layer of fibrous tissue, resembling a ring-porous arrangement. If, however — as it happens in many annual rings — the fibrous tissue fails to form, the ring approximates in its appearance the structure characteristic of diffuse-porous species.

In the ring-porous category, the following two groups can be distinguished: (a) species in which a sharp decrease can be seen in the number and size of pores, but there is a similarity in the arrangement of pores in early and late wood, e.g. *Quercus infectoria Osyris alba* (Figure 4) and (b) species which show a difference in pore arrangement between early and late wood, e.g. *Alnus orientalis* (Figure 1), *Lycium barbarum* (Figure 19), *Rhus Coriaria*.

A quantitative analysis of the data obtained indicates thet the most commonly en-

countered pattern of pores is mostly solitary, partly in multiples. The majority of multiples (62 per cent) is composed of 2, 2—4, 2—5 or, less frequently, 2—6 pores. Of these 30 per cent have multiples consisting of two or varying between two and three pores. The lumen of pores is usually variable, elongated in different directions, its shape often varying in the same species from orbicular to angular.

The largest pore-size group consists of very small pores (with tangential diameter less than 50 μ) and accounts for 38 per cent of the surveyed vegetation — mostly shrubs and sub-shrubs. 34 per cent of trees and shrubs are in the moderately small-size bracket (50—100 μ). Medium-sized pores (100—200 μ) are found in about 22 per cent of the species — almost exclusively trees. Only a few tree species have moderately (200—300 μ) or very large (over 300 μ) pores.

Paratracheal wood parenchyma, particularly its vasicentric form, constitutes another feature of the indigenous vegetation and is particularly abundant among xerophytous and desert plants. Paratracheal parenchyma was found in 66 per cent of the species. Most of the sub-shrubs have a diffuse sparse parenchyma.

70 per cent of the species possess fine rays and 14 per cent medium-sized ones; broad rays are seldom encountered. About 51 per cent of the species have 25—50 rays per 5 mm, as measured in the tangential direction of the cross-section; in 37 per cent the frequency of rays is below 25, while 12 per cent have 25—50 rays per 5 mm.

Another common feature, represented in more than half of the species, is the presence of crystals. In some plants there is a concentration of crystals in the late wood, close to the periphery of the annual ring.

Anomalous anatomical structure due to strands of phloem among the xylem elements, as described by Chalk and Chattaway[2], is found in certain desert species belonging to the families *Chenopodiaceae*, *Salvadoraceae*, *Buxaceae*, *Menispermaceae*, etc. A similar anomaly has been recorded in desert plants of other regions, for instance in *Leptoderia pyrotechnica* and *Cocculus pendulus* of the Sahara as well as in such dominant shrubs of the Californian deserts as *Simmondsia*, *Graya*, *Eurotya* and *Atriplex* spp.

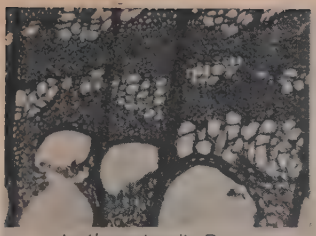
In contrast to the majority of xerophytic and desert species which are characterized by a well-developed mechanical tissue, the wood of hydrophytes such as *Populus* spp., *Salix* spp. *Nerium Oleander*, *Vitex Agnus-castus* and *Platanus orientalis*, is largely composed of abundant vascular elements and reticulate thin-walled tissue, while parenchyma and fibrous tissue are sparse or insignificant.

Microphotographs of cross-sections of the more important species are presented at the end of the paper. An attempt has been made to show clearly the arrangement of pores in the various parts of the annual ring. The boundary between two adjoining rings can be seen in most cases. All the illustrations represent the same magnification, thus making for easy comparison of the size of various anatomical elements.

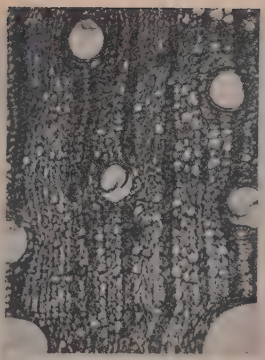
SUMMARY

The wood anatomy of most indigenous arborescent species, largely of silvicultural imporance, was investigated.

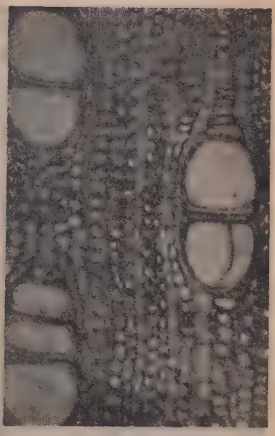
A correlation has been established between classified anatomical features and the foliar aspect. The majority of evergreens are diffuse-porous, whereas deciduous species



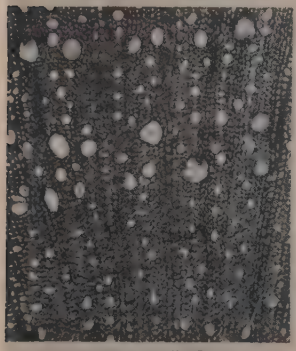
1. *Alnus orientalis* Decne.



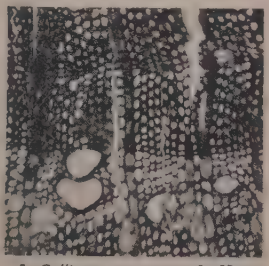
2. *Q. ithaburensis* (Decne) Boiss.



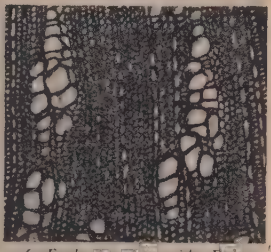
3. *Ficus carica* L.



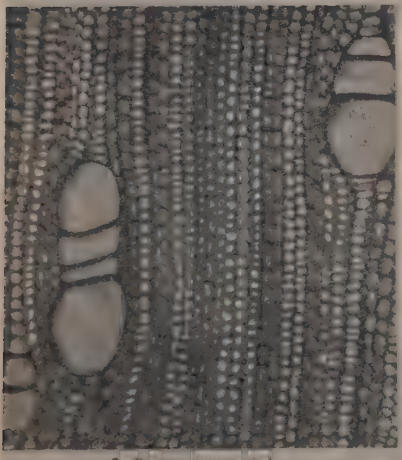
4. *Osyris alba* L.



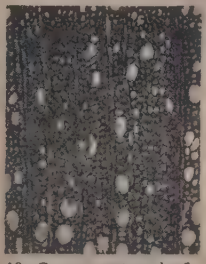
5. *Calligonum comosum* L. Her.



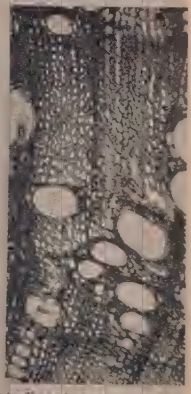
6. *Euphorbia thamnoides* Boiss.



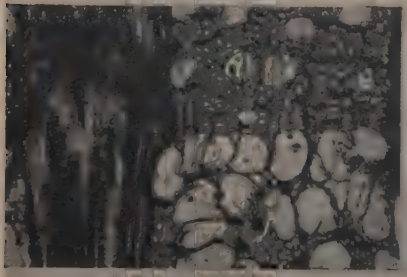
7. *Ricinus communis* L.



10. *Crataegus Azarolus* L.



11. *Poterium spinosum* L.



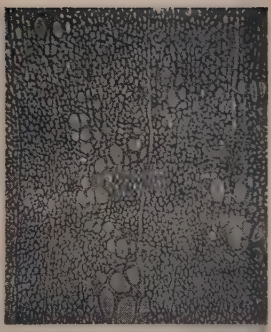
8. *Platanus orientalis* L.

9. *Clematis cirrhosa* L.

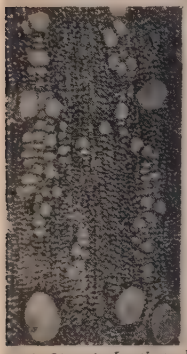
12. *Prunus Amygdalus* Stocks.

13. *A. Raddiana* Savi.

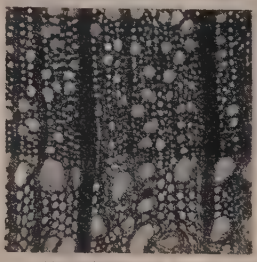
14. *Prosopis Stephaniana* (Willd) Spreng.



15. *Thymelaea hirsuta* L. Endl.

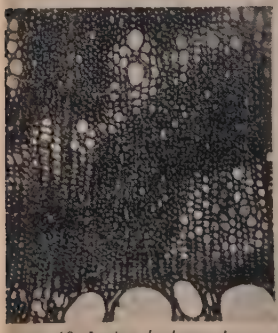


16. *Pistacia Lentiscus* L.

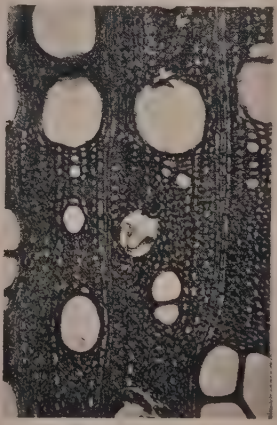


18. *Arbutus Andrachne* L.

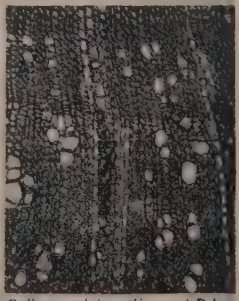
17. *Zizyphus spina-Christi* (L.) Willd.



19. *Lycium barbarum* L.

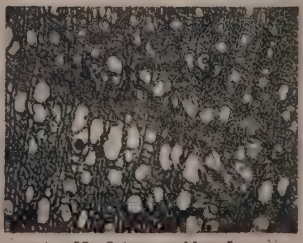


20. *Vitex Agnus-castus* L.

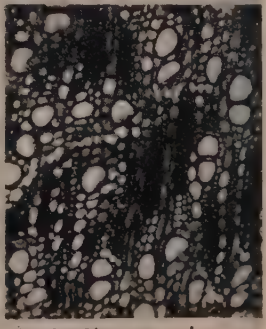


21. *Ballota undulata* (Fresen.) Bth.

23. *Nerium Oleander* L.



22. *Origanum Maru* L.



24. *Olea europaea* L.

mostly possess a ring-porous structure. Intermediate wood structure is to be found in both groups. The anatomy of broom-like species which are classed as semi-deciduous, approximates that of evergreen and intermediate plants.

Desert species of *Chenopodiaceae* and some other families have an anomalous wood structure in that strands of phloem are embedded in the xylem.

The paratracheal type of parenchyma is the most prevalent, especially its vasicentric variant.

The energetic resumption of cambium activity after the prolonged hot and dry season, accounts for the formation of larger pores in the early wood, even in evergreens.

The pores are mainly solitary and in multiples, mostly of two or two and three combined. Pores of small size are most frequent.

Fine rays are dominant, except in a few species, like the oaks, oriental plane tree and climbers.

The occurrence of crystals, often of a large size, is frequent.

ACKNOWLEDGEMENT

The author is grateful to Professor L. Chalk of Oxford for his criticism and valuable suggestions. He also wishes to express his thanks to Professor M. Evenari, of the Hebrew University, and to Mr. N. Landau and Miss M. Balaban of the Research Council of Israel for their kind advice and assistance in the revision of the manuscript and for aid in its publication.

REFERENCES

1. Bews, J. W., 1927, *New Phytologist*, **27**, 132.
2. Chalk, L. and Chattaway, M. M., 1937, *Trop. Woods*, **50**, 1.
3. Evenari, M., 1938, *Linn. Soc. Jour. Bot.*, **51**, 383.
4. Huber, B., 1935, *Ber. deutsch. bot. Gesells.*, **53**, 710.
5. International Association of Wood Anatomists, 1935, *Trop. Woods*, **36**, 1.
6. International Association of Wood Anatomists, 1939, *ibid.*, **59**, 51.
7. Messeri, A., 1938, *Soc. Bot. Italiana, Firenze.*
8. Oppenheimer, H. R., 1945, *Pal. Jour. of Botany, Rehovot Series*, **5**, 22.
9. Radlkofer, S., 1883, *Ueber die Methoden in der Botanik, insbesondere die anatomischen Methoden*, Muenchen.
10. Record, S. J., 1936, *Trop. Woods*, **47**, 12.
11. Simon, I., 1902, *Der Bau des Holzkoerpers von Sommer und Winter gruenen Gewaechsen und seine biologische Bedeutung*, Berlin.
12. Solereder, H., 1908, *Systematic Anatomy of Dicotyledons*, Stuttgart.
13. Webber, I. E., 1936, *Amer. J. Bot.*, **23**, 181.

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter*	Perforation	Parenchyma	Ray Sructure	Ray Width*	Ray Height*	Number of rays per 5mm	Crystals	Remarks
Alnus orientalis Decne. Fig. 1. Deciduous tree	Distinctly 2-sized. Early wood pores solitary v. large, tangentially or radially elongated. Late wood pores clustered, small, often joined into oblique bands	Ring-porous	70-170	Simple	Diffuse, sparse	Mostly 2-3 seriate some 4-seriate or one-celled	10-30	185-280	30-40		No measurements of small pores were made, because of irregular lumen
Quercus calliprinos Webb. Evergreen tree	Solitary, in radial or oblique rows which are sometimes branched	Intermediate	20-95	Simple	Meta-tracheal and diffuse	1-celled and and multi-seriate	10-12	60-320	400-2800	Frequent in rays	Bands of fibrous tissue penetrating into medullary rays. No multi-seriate wood rays in young branches. Boundaries of rings undulate
Q. infectoria Oliv. Deciduous tree	Solitary, in radial or oblique rows. Lumen round, radial or oblique	Ring-porous	20-160	Simple	Diffuse, sometimes in rad. or tangent. uni-seriate lines	1-celled and and multi-seriate	10-15 25-230	65-5000 and more		Large, frequent along ring boundaries	
Q. ithaburensis (Decne) Boiss. Fig. 2. Deciduous tree	Solitary, mostly radial	Ring-porous	40-225	Simple	Diffuse, radial. Also single. radiallv arranged rows of cells	1-celled and multi-seriate	10-15 and 150-800	100-5500 and more			Boundaries of rings undulate
Populus euphratica Oliv. Deciduous tree	Solitary and in rad. multiples of 2-3, more rarely of 4	Intermediate	20-80	Simple	Fusiform, sparse	1-celled some 2-seriate	10-25	90-550	45-55	Abundant only in very young stems	Main body consisting of pores and thin-walled reticulate tissue. No fibrous tissue
Salix alba L. Deciduous tree	Mostly solitary; some in multiples of 2-3	Intermediate	10-50	Simple	Not evident	1-celled	9-12	120-640	11-13		
Ficus carica L. Fig. 3. Deciduous tree	Solitary and in multiples of 2-3, seldom of 4	Diffuse-porous	28-110	Simple	Paratracheal, almost confluent in wide layers	2-5-seriate	15-50	185-950	20-25	Frequent	No clearly - defined vasicentric parenchyma in branches. Boundaries of annual rings indistinct
F. Sycomorus L. Evergreen tree	Solitary and in multiples of 2	Diffuse-porous	50-170	Simple	Paratracheal, in thick bands	Multi-seriate	40-120	100-650	15-20		

* All measurements are in microns.

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Osyris alba L. Fig. 4. Broom-leaved, sub-shrub	Solitary, rarely in multiples of 2	Ring-porous	10-40	Simple	Not evident outside rays	2-3-seriate	20-50	200-1600	20-25		Cells of wood rays mostly elongated vertically
Calligonum comosum Fig. 5. L. Her. Broom-leaved shrub	Solitary, or in multiples of 2-6, radially arranged	Intermediate	15-50	Simple	Paratracheal and terminal	1-celled and 2-seriate	12-28	80-360	25-35		Pores and fibres often filled with a yellow fluid
Atriplex Halimus L. Evergreen shrub	Vascular bundles and phloem elements embedded in xylem parenchyma. Radial multiples or small clusters. Lumen rad. or tangent. elongated, sometimes orbicular	Diffuse-porous	20-90	Simple	Paratracheal, large-celled tang. bands	Not evident				Frequent in parenchyma	Anomalous wood - structure
Salsola tetrandra Forsk. Sub-shrub	Bundles of pores and phloem. Lumen orbicular, also rad. or oblique elongated	Diffuse-porous	10-25		Paratracheal, surrounding bundles	1-celled and 2-3-seriate	10-32		8-13	Frequent at ring - boundaries	Annual rings indistinct. Fibrous tissue occupies most of the ring-area
Suaeda asphaltica Boiss. Evergreen shrub	Bundles of pores and phloem embedded in xylem	Diffuse-porous	10-45		Confluent forming tangential bands					Frequent	
Haloxylon persicum Bge. Broom-leaved shrub	Pore bundles and phloem bands embedded in xylem. Lumen orbicular or variously elongated	Diffuse-porous	10-130		Vasicentric, thin-walled large cells	2- to multi-seriate	20-185		13-18		Width of rays decreasing in passage through fibrous tissue
Euphorbia thamnoides Fig. 6. Boiss. Small broom-leaved tree	Mostly in rad. bands of varying width; also in clusters. Lumen variable	Diffuse-porous	15-40	Simple	Adjoining pores, sparse	Mostly 1-celled; also 2-seriate	12-30		40-55		
Ricinus communis L. Fig. 7. Evergreen tree	Solitary and in multiples of 2-5; also in radial lines. Lumen variable	Diffuse-porous	40-120	Simple	Paratracheal and diffuse, sparse	Mostly 1-celled and 2-seriate; some 3 - seriate	10-28	270-1280	20-25		
Platanus orientalis L. Fig. 8. Deciduous tree	Solitary and in multiples of 2, mostly angular. Lumen orbicular or variously elongated	Ring-porous	32-90	Simple	Diffuse and terminal	1-celled to multi-seriate	10-260	up to 5000 and over	10-15	Frequent	Wood rays thicker at boundaries of annual rings

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Laurus nobilis L. Evergreen shrub or small tree	Solitary or in multiples of 2, more rarely 3	Diffuse-porous	14-28	Simple	Paratracheal, often forming monocellular tangent. bands	1-celled and 2-seriate	12-40	70-400		Frequent	Secretion cells filled with essential oil
Clematis cirrhosa L. Fig. 9. Evergreen climber	Solitary and in multiples of 2-3, in wide rad. layers. Lumen variously elongated	Diffuse-	10-80	Simple	Not evident		110-600	up to 10,000 and over	3-5		Fibrous tissue undeveloped. Large, thin-walled cells
Capparis spinosa L. Deciduous shrub	Solitary and in multiples of 2-4	Diffuse-porous	25-110	Simple	Paratracheal, more concentrated at boundaries of annual rings	Mostly 1-celled and 2-seriate, some 3-seriate	10-40	95-385	25-30		Rays not evident in very young shoots
Maerua crassifolia Forsk. Evergreen shrub	Solitary and in radial lines. Lumen variously elongated	Diffuse-porous	15-45	Simple	Paratracheal, sparse	Mostly 1-celled, some 2-seriate	4-20	80-650	35-40	Present	Mono-cellular rays of two different thicknesses
a lviaefolius L. Evergreen shrub	Exclusively solitary, numerous, diminishing in size and number only near boundary of annual ring	Diffuse-porous	8-35	Simple	Diffuse, sparse	Mostly 1-celled, some 2-seriated	8-25	30-320.	25-40		
C. villosus L. Evergreen shrub	Mostly solitary, some in multiples of 2, clusters or oblique lines; unevenly distributed	Intermediate	12-45	Simple	Diffuse, sparse	Mostly 1-celled, some 2-seriate	7-20	65-385	11-14		Lignified band of late wood, with relatively small pores
Tamarix articulata Vahl. Evergreen tree	Solitary and in multiples of 2-3	Diffuse-porous	20-65	Simple	Paratrachael	Exclusively multi-seriate	50-190		10-15	Present; frequent in rays	
T. maris-mortui Evergreen shrub	Solitary and in multiples of 2-3 Lumen variously elongated	Intermediate	20-50	Simple	Paratracheal and fusiform	Mostly 1-celled	15-50	150-1000	15-20	Crowded in rays	
T. pseudo-Pallasii Gutm. Evergreen shrub	Solitary, in radial multiples and lines	Diffuse-porous	25-100	Simple	Paratrachеal	Mainly multi-seriate, some 3-4-seriate	40-150	100-1200	15-20	Frequent in rays, particularly near margins	

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Crataegus Azarolus L. Fig. 10. Semi-deciduous shrub	Solitary, angular, very numerous	Intermediate	12-30	Simple	Vasicentric, sparse	1-celled and 2-3 seriate	12-28	80-500	7-10	Frequent	Difference in size of pores between early and late wood becomes apparant only in the younger rings of relatively old trees
Pyrus syriaca Boiss. Deciduous tree	Solitary and in multiples of 2. Lumen angular, variously elongated	Diffuse-porous	15-35	Simple	Not evident outside rays	1-celled and 2-seriate	12-27	80-550	40-48		Spiral thickenings on vessel walls
Poterium spinosum L. Fig. 11. Deciduous sub-shrub	Solitary and in multiples of 2-5, some in clusters or rad. lines. Lumen variously elongated	Diffuse-porous	25-100	Simple	Vasicentric, abundant	Mostly 1-celled, some 2-seriate	8-20	40-280	35-40	Mostly adjoining pores	
Prunus Amygdalus Stocks. Fig. 12. Deciduous tree	Two-sized. Large, solitary at ring-boundaries or in tangent. arranged multiples of 2-3. Small in remainder of ring area, mostly solitary, also in multiples of 2-3	Ring-porous	40-95 8-32	Simple	Terminal, in tangent bands at ring boundaries	Mostly 2-6 seriate, some mono-cellular	8-55	120-950	3-5	Present around pores; more numerous in rays	Fibrous tissue well developed
Rubus sanctus Schreb. Evergreen shrub	Solitary, in multiples of 2-3 and in clusters	Diffuse-porous	15-50	Simple	Not evident	4- to multi-seriate	30-50	Very long	15-20		
Sorbus trilobata Labill. Deciduous tree	Mostly solitary, some in tangent. arranged multiples of 2-3. Lumen rad. elongated	Diffuse-porous	15-55	Simple	Diffuse, sparse	Mostly 2-3 seriate, some 1 celled	8-27	50-560	35-45	Present	
Acacia albida Delile. Evergreen tree	Two-sized. Large, mostly solitary. Small in multiples of 2-4. Radially elongated	Diffuse-porous	80-155 30-60	Simple	Paratracheal, in wide concentric bands	Mostly 1-celled, some 2-seriate	15-20	65-160	12-13	Present, mainly at ring boundaries	Fibrous tissue very lignified and poreless: less abundant than parenchyma
A. Raddiana Savi. Fig. 13. Deciduous tree	Mostly solitary; also multiples of 2-3. Orbicular and rad. or tangent. elongated	Intermediate	45-150	Simple	Paratracheal, in tangent. bands	3-6, mostly 4-seriate	18-55	100-560	10-20	Frequent in parenchyma, mainly at ring boundaries	Fibrous tissue, forms a pore-less band of ring-boundary. Width of the band and degree of diminution in size of pores are subject to seasonal fluctuations

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
A. spirocarpa Hochst. Evergreen tree	Mostly solitary, some in multiples of 2. Sparse	Diffuse-porous	85-180	Simple	Paratracheal, in thin-walled, often confluent bands. Frequently joining up with rad. lines of parench. cells	3-4 seriate	30-50	90-560	13-20	Present in parenchyma. Smaller than in A. Raddiana	Width of rays decreases in passage through parenchyma. Fibrous tissue very lignified, with largely lumen-less cells
Anagyris foetida L. Deciduous shrub	Clusters, mostly in tangential or oblique, undulating bands	Diffuse-porous	15-30	Simple	Paratracheal	Mostly 2-3 seriate; some 1-celled	12-28	80-800	20-25		The plant is exceptional among indigenous broad-leaved species in being leafless during the dry season. Some pores are filled with a coloured substance
Calycotome villosa (Vahl.) Lk. Broom-leaved shrub	Mostly in clusters, often joining in rad. or oblique bands. Some solitary and multiples of 2-3 or in short rad. rows	Diffuse-porous	12-35	Simple	Paratracheal	1-celled and 2-3 seriate	6-28	80-550	25-40		In annual rings containing a band of late wood, the structure resembles the intermediate type
Ceratonia Siliqua L. Evergreen tree	Solitary and in multiples of 2-4, radially arranged, evenly distributed	Diffuse-porous	30-100	Simple	Vasicentric, abundant. Also metatracheal in uniseriate radial lines at ring boundaries	Mostly 2, 3 and 4-seriate; more rarely 1-celled	20-40	90-720	25-33	Present. Crowded at ring boundaries	In branches pores are radially arranged and parenchyma dominates over the fibrous tissue
Cercis Siliguastrum L. Deciduous tree	Solitary and in multiples of 2-3, more rarely 4. Often forming wavy radial layers	Intermediate	15-65	Simple	Mostly vasicentric; also termina l	1-celled, 2, 3 and 4-seriate	8-30	50-415	35-40	Mostly around pores	
Indigofera argentea L. Deciduous tree	Mostly solitary; some in multiples of 2-3. Mostly angular. Unevenly distributed. Lumen orbicu lar or rad. or tangent. elongated	Diffuse-porous	10-20	Simple	Vasicentric; also joined into tangent. bands	1-celled	8-12		25-35		
Prosopis Stephaniana (Willd) Spreng. Fig. 14. Evergreen shrub	Solitary and in multiples of 2, more rarely 3	Diffuse-porous	25-145		Vasicentric, often joined into tangent. lines	1-celled and 2-3 seriate	10-40		25-35	Frequent	

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Retama Roetam Webb. Broom-leaved shrub	Solitary, in clusters and oblique, variously branched, rows	Diffuse-porous	12-35	Simple (?)	Vasicentric, partly confluent	1-celled and 2-3 seriate	8-20	80-360	30-40		Vasicentric arrangement of parenchyma not clearly defined in young shoots. Fibrous tissue well developed
Thymelaea hirsuta L. Endl. Fig. 15. Evergreen shrub	Mostly in clusters and in flame-like or dendritic arrangements	Diffuse-porous	7-32	Simple	Metatracheal, sparse	Mostly 1 - celled, also 2-3 seriate	7-9	40-280	55-65		
Grewia villosa Willd. Evergreen shrub	Solitary, in multiples of 2-3, in radial lines of 7-8 and in small clusters. Lumen orbicular or variously elongated	Diffuse-porous	15-55	Simple	Paratracheal, sparse	1-celled and 2-3 seriate	10-30		15-20		
Balanites aegyptiaca Del. Evergreen tree	Solitary and in rad. or oblique lines; also in clusters. Lumen orbicular or variously elongated	Diffuse-porous	40-100	Simple	Mostly apotracheal: also vasicentric	4-30 cells wide	20-190	135-1360	5-10	Frequent in rays	Deposition of gum in vessels
Zygophyllum dumosum Boiss. Evergreen sub-shrub	Mostly solitary: also in multiples of 2-3. Lumen variously elongated	Diffuse-porous	10-30	Simple	Paratracheal	Mostly 2-3 seriate; also 1-celled	14-25	120-560	15-25	Frequent	
Pistacia Lentiscus L. Fig. 16. Evergreen shrub	Solitary, in multiples of 2-3 and in groups of 5-8 mostly radially arranged	Diffuse-porous	10-55	Simple	Paratracheal, abundant in early wood	1-celled and 2-seriate	10-15		35-45		Spiral thickenings on vessel walls. Oleoresin secretory canals in the bast of stem and roots and in leaves
P. palaestina Boiss. Deciduous shrub	Solitary, large, at boundary of early wood: Small, in oblique rows or clusters in late woods	Ring-porous	15-95	Simple	Vasicentric, partly confluent. Some parench. cells radially arranged	2-3 seriate	20-30	70-360	10-20		Distribution of pores in very young stems approaches the diffuse - porous type. Spiral thickenings on vessel walls. Oleoresin canals as in P. Lentiscus
Rhus Coriaria L. Small deciduous tree	Large solitary and in multiples of 2-3 in early wood. Small, in clusters in late wood	Ring-porous	50-140 10-20	Mostly scalariform; also simple	Paratracheal and terminal	Mostly 1 - celled, also 2-seriate	10-20	60-420	10-20		Thyloses abundant, particularly in heartwood

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
R. oxyacanthoides Dumert. Sarub	Mostly in multiples: also in lines of 2-7	Diffuse-porous	10-50	Simple	Paratracheal: also in radial lines	Mostly 1-celled, also 2-seriate	10-12	80-360	25-35	Frequent, especially at ring boundaries and in rays	Thyloses abundant in heartwood
Acer syriacum Boiss. et Gaill. Deciduous tree	Mostly solitary; also in radially arranged multiples of 2-4	Diffuse-porous	28-40	Simple	Diffuse, sparse	1-celled and 2-4 seriate	12-28	80-950	35-45	Frequent; solitary or in multiples	
Rhamnus Alaternus L. Small evergreen tree	Mostly in branched radial or oblique rows and bands of various thickness: some solitary and in multiples of 2-4	Diffuse-porous	20-40	Simple	Vasicentric, sparse	1-celled and 2-4 seriate	7-30	50-320	25-30		Mucilage cells present, particularly frequent at ring boundaries
R. palaestina Boiss. Semi-deciduous shrub	Arrangement flame-like or dentritic. More numerous than in R. Alaternus	Diffuse-porous	12-28	Simple	Vasicentric	1-celled and 2-3 seriate	10-28	50-720	40-45	Frequent, large; in and outside rays	Crowding of pores at ring boundaries and diminution of their size in late wood more pronounced than in R. Alaternus
Zizyphus Lotus (L.) Lam. Semi-deciduous shrub	Solitary in multiples and radial rows. Thick-celled Much smaller in branches. Lumen variable	Diffuse-porous	25-95	Simple	Vasicentric	Mostly 1-celled in 2 different widths; also 2-seriate	7-10 18-23	135-800	50-60	Present in rays	Fibrous tissue well developed
Z. spina-Christi Fig. 17. (L.) Willd. Deciduous tree	Solitary and in multiples of 2, more rarely 3. Evenly distributed	Diffuse-porous	35-110	Simple	Paratracheal	1-celled of 2 different widths	8-20	80-900	55-60	Frequent	
Arbutus Andrachne L. Fig. 18. Evergreen tree	Solitary and in radially arranged multiples of 2-3; angular. Lumen orbicular or rad. elongated	Diffuse-porous	20-40	Simple	Diffuse-Sparse	Mostly 2-3 seriate; more rarely 1-celled	10-30	90-230	10-15	Mostly at ring boundaries; also in rays	
Styrax officinalis L. Deciduous shrub	Solitary and in multiples of 2-5	Intermediate	10-50	Scalariform	Diffuse. Sparse	1-celled and 2-3 seriate	10-50	80-650	35-45	Present	Some cells filled with a coloured substance
Lycium barbarum L. Fig. 19. Deciduous shrub	Large: solitary, concentrated in early wood. Small: in flame-like or dendritic arrangement. Lumen variously elongated	Ring-porous	10-110	Simple	Vasicentric	Mostly 1-celled; also 2-seriate	10-20	80-800	40-50		

Species	Arrangemnt of Pores	Pore Distribution	Pore Diameter	Perforation	Parenchyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Vitex Agnus-castus L. Fig. 20. Deciduous shrub	Solitary and in multiples of 2-3	Intermediate	25-110	Simple	Metatracheal in concentric lines	2-3 seriate	20-50	95-1350	30-35		
Ballota undulata (Fresen.) Bth. Fig. 21. Evergreen sub-shrub	Solitary, in multiples of 2-4 and small clusters; mostly angular. Lumen variable	Diffuse-porous	10-30	Simple	Diffuse, sparse	1-celled and 2-4 seriate	15-47	150-1200	6-7	Present in rays	
Origanum Maru L. Fig. 22. Evergreen sub-shrub	Solitary and in variously arranged multiples of 2-3	Intermediate	14-35	Simple	Paratracheal, sparse, occasionally radially arranged, parench. cells	1-celled	10-12	80-320	45-50		
Salvia graveolens Vahl. Evergreen shrub	Solitary, in multiples of 2-4 and small clusters	Diffuse-porous	10-35	Simple	Paratracheal	2-4 seriate	20-50	100-950	15-20		
S. triloba L. Evergreen sub-shrub	Solitary and in multiples of 2-3. Lumen mostly radially elongated, sometimes tangentially	Intermediate	8-50	Simple	Diffuse, sparse	Mostly 1-celled and 2-seriate, more rarely 3-seriate	7-25	55-480	13-16	Frequent in and outside rays	Pores, particularly in early wood, filled with a coloured substance
Teucrium creticum L. Evergreen sub-shrub	Mostly solitary; also in multiples of 2-3	Intermediate	10-35	Simple	Diffuse, sparse	Mostly 1-celled; some 2-seriate	8-12	40-480	40-50		
Thymbra spicata L. Evergreen sub-shrub	Solitary and in multiples of 2-5. Lumen radially elongated	Ring-porous	12-27	Simple	Vasicentric and in radial rows	Not evident					
Nerium Oleander L. Fig. 23. Small evergreen tree	Solitary and in radially arranged multiples of 2-5. Pores evenly distributed	Diffuse-porous	20-45	Simple	Diffuse or surrounding pores	1-celled	10-15	55-390	12-14	Present	Reticulate tissue prominent. No fibres. Some pores filled with a coloured substance
Calotropis procera (Willd.) R. Br. Evergreen tree	Solitary end in radially arranged multiples of 2-5. Lumen variously elongated	Diffuse-porous	28-105	Simple	Paratracheal and diffuse; sparse	Mostly 1-celled; also 2-seriate	12-30	95-800	25-30		Annual rings indistinct. Many aggregate rays appear in longitudinal section. Thyloses in many vessels
Olea europaea L. Fig. 24. Evergreen tree	Solitary, in multiples of 2-4 and radial lines. Evenly distributed	Diffuse-porous	20-45	Simple	Paratracheal	1-celled and 2-seriate	15-20	90-360	35-40		Formation of the largest pores in early wood sets in after some delay

Species	Arrangemnt of Pores	Pore Distri-bution	Pore Dia-meter	Perfor-ation	Paren-chyma	Ray Structure	Ray Width	Ray Height	Number of rays per 5mm	Crystals	Remarks
Phillyrea media L. Evergreen shrub	In clusters and in flame-like or dendritic arrange-ment. Lumen angular and radially elongated	Diffuse-porous	8-27	Simple	Terminal and para-tracheal; sparse	Mostly 1 - celled; also 2-seriate	10-20	60-200	40-50		
Lonicera etrusca Santi. Evergreen climber	Solitary, in multiples and radial lines. Angular	Diffuse-porous	10-28	Simple	Not evid-ent	1-celled and 2-3 seriate	15-30	100-950	25-35		
Inula viscosa (L.) Desf. Evergreen sub-shrub	Solitary and in mostly rad. sometimes tangent. arranged multiples of 2, more rarely 3. Lumen variable and variously elongated	Diffuse-porous	15-40	Simple		Mostly multi - ser - iate; also 1-celled	20-135	480-1840	10-15	Frequent	Some pores filled with inuline

BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL

Volume II September 1952 No. 2

CONTENTS

BRAUN, I., SCHOENFELD-REINER, R. and TRAUM, E., An Investigation into the rheological properties of bitumen. II. A contribution to the theory of the constant-load extensometer 89
RIGBI, Z., A tetrahedral representation of the relationship of four phases 99
LEVINE, M., The composition of hypobromite solutions at various pH values and bromide concentrations 101
HALPERIN, A. and SAMBURSKY, S., Determination of RbCl in rubidium-enriched Dead Sea carnallites 107
BLOCH, M. R., KERTES, S. and LOWY, D., Some observations on the decomposition of carnallite 115
YARON, F. and HEITNER, M., The chloride-bromide ratio of the water sources of Eastern Emek Yezreel and of the Beisan Valley 118
YARON, F., The springs of Lake Kinnereth and their relationship to the Dead Sea 121
ROSENHECK, K., PILNIK, W., MONSELISE, J., GUERON, J. and HABER-SCHEIM, S., Chemical studies on tomatoes grown in Israel 129
PILNIK, W. and ROTHSCHILD, GERDA, Studies on the pectase activity of tomatoes 135
HAGIN, J., The active lime content of soil as a factor in the development of chlorosis 138
PICARD, L., The Pleistocene peat of Lake Hula 147
BENTOR, Y., Air-photographs and geological mapping with special reference to the geological conditions in the Negev (Southern Israel) 157
FELDMAN-MUHSAM, B On the identity of *Rhipicephalus Sanguineus* Lat 187

LETTERS TO THE EDITOR:

COHEN, S. and BAUMINGER, R., A search for the natural radioactivity of vanadium.. 195
RIM, M., The collection of atmospheric dust 195
SCHNERB, I. and YARON, F., On the solubility of sodium chloride in Dead Sea brines 197
BERGMANN, E. D. and BENDAS, H., The reactivity of the α-hydrogen in α-amino esters 198
OLITZKI, A. L. and KUSHNIR, R., The immunizing potency of living *Brucella abortus* vaccines tested in lethal infections of white mice produced with the aid of the mucin technique 199
ADLER, S. and FELDMAN-MUHSAM, B., Infection of suckling mice with a Nuttallia of *Meriones tristrami* 201
ADLER, S. and FELDMAN-MUHSAM, B., Transmission of a Nuttallia of the gerbil *Meriones tristrami* by *Rhipicephalus sanguineus* Lat S. Str. 201
SHELESNYAK, M. C., Inhibition of deciduoma formation by antihistaminic agents .. 202
ADLER, S. and MEEROVITCH, E., The action of colchicine on colchicine-resistant strains of *Trichomonas vaginalis* Donne 202

9TH MEETING OF THE MICROBIOLOGICAL SOCIETY OF ISRAEL

Summaries of papers presented in the Virus Section

KOMAROV, A. and HORNSTEIN, K., The effect of serial passages in embryonated eggs on the pathogenicity of rabies virus 204
HIRSCH, W., Pleuropneumonia-like organisms in pelvic abscess 207
BERNKOPF, H. and LEVINE, S., A survey of antibodies against the Lansing strain of poliomyelitis in the Israel population 207
RABINOVITZ, E. and BERNKOPF, H., Susceptibility of suckling mice to infection with *Vaccinia* and *Variola* viruses 207
LEVINE, S. and BERNKOPF, H., The occurrence of *Coxsackie* viruses in Israel 208
BERNKOPF, H. and LEVINE, S., Some properties of a virus isolated from the blood of a sick child during an epidemic in Maayan Tsevi 209
OLEJNIK, E., SCHMUTZKA, E. and GINSBURG, Y., Isolation of neurotropic viruses.... 209
OLEJNIK, E., Infectious adenitis transmitted by *Culex molestus* 210
GOLDSMIT, LEAH and KOMAROV, A., The causative agent of *Psittacosis* in Israel 211

GOLDSMIT, LEAH and KOMAROV, A., Blue tongue in cattle and sheep in Israel 211
KOHN, A., Immunization of chicken with atomized living Newcastle disease virus vaccine 211
KOHN, A., Resistance to drying of bacteriophages of *E. Coli* in the T group 212
MAGER, J. and AMINOFF, D., The haemagglutinin of *Vibrio comma* and its relation to the receptor destroying enzyme 212
GOLDWASSER, R. and SHELESNYAK, M. C., A syringe carrier and egg clamp for intravenous inoculation of the chick-embryo 212

Summaries of Papers Presented in the Section of General Microbiology and Chemotherapy

TURNER-GRAFF, RUHAMA, An effective use of Petri dishes for microcultures..... 213
ADLER, S., BOCK, A. and SADOVSKY, A., *T. vaginalis* in the study of resistance problems 213
BERGMANN, ERNST D., and SICHER, SARAH, The mode of action of chloramphenicol 214
AVIDOR, J. and YANIV, H., Population changes in *Bacterium tularense* as revealed by changes in susp ension stability. I. Mutual effect of agglutinable (S.A.) and non-agglutinable (N.S.A.) types. II. The stability of *Bact. tularense* in the presence of electrolytes 214
BABAD, A., PINSKY, A., TURNER-GRAFF, R. and SHARON, N., An anti-fungal substance from *Bacillus subtilis* 214
FARKAS, HANNA, Determination of CO_2 fixation by *water vibrio* with the aid of radioactive carbon 215
BERGNER-RABINOWITZ, S., Sewage purification and utilization 215
RAUBITSCHEK, F., Problems of dimorphism of dermatophytes 216

NEWS AND VIEWS 218

SUPPLEMENT:

GINDEL, I., Anatomical features of the indigenous woody vegetation in Israel (under separate cover) 1-18

AN INVESTIGATION INTO THE RHEOLOGICAL PROPERTIES OF BITUMEN II. A CONTRIBUTION TO THE THEORY OF THE CONSTANT-LOAD EXTENSOMETER

I. Braun, R. Schoenfeld-Reiner and E. Traum
Rheological Laboratory, Hebrew Institute of Technology, Haifa

It is shown that when a two-phase material consisting of a continuous elastic solid phase and a dispersed viscous liquid phase is tested in a constant-load extensometer and the extension (Δl) referred to the instantaneous length (l) per initial traction (p_o) is plotted against time; if observations from experiments in which the initial traction is varied lie all on *one* curve of exponential-like shape, this proves that the solid phase obeys the simple Hooke-law of elasticity and the liquid phase the simple Newton-law of viscosity. This theory is confirmed by observations on an oxidized bitumen at a temperature of 25° C.

1. Introduction

In a first communication[7] attention was drawn to the fact that the usual rheological analysis of elastico-viscous materials, such as certain bitumens, is inadequate, when they are subjected to large strains. It was therefore, in the course of an investigation into the rheological properties of bitumen undertaken under the sponsorship of the Research Council of Israel, necessary to develop a theory for the interpretation of large deformations involving large strains and to check the theory by means of suitable observations. The present communication contains such a theory for the extensometer used in the investigation and previously described and reports on experiments selected for that purpose.

For these reasons Lethersich[3] and Reiner[6] have used constant-*load* extensometers in their rheological investigations of bitumen. When recording his experiments, Lethersich plotted the percentage longitudinal deformation

$$D_l^C = \Delta l / l_o \qquad (1.3)^*$$

against time, the slope of the curve being a measure of the rate of deformation $\dot{D}$. Because of the gradually increasing traction p, $\dot{D}$ also gradually increases and even when the material is a simple Newtonian liquid with constant viscosity η, the D_l^C versus t curve is not a straight line, but convex towards the t axis. The theoretical

*The superscript C indicates deformation "as defined by Couchy" the subscript l indicates "longitudinal" deformation.

Received March 1952.

evaluation of such a curve is complicated. It was therefore fortunate that Lethersich[4] later discovered that when the longitudinal deformation is plotted in a measure proposed by Swainger[9], namely related to the extended length

$$l = l_o + \Delta l \tag{1.4}$$

and measured by

$$D_l^S = \Delta l / l = (l - l_o) / l = 1 - l_o / l \tag{1.5}$$

the curve is, for a simple Newtonian liquid, a straight line. This relation can be derived from the law of extensional flow of a simple Newtonian liquid as follows:

During the extension of the prismatic specimen one end is fixed and the other travels with the velocity

$$v_l = dl / dt = \dot{l} \tag{1.6}$$

The extensional "flow" is

$$f_l = v_l / l = \dot{l} / l = \frac{d}{dt}(\ln l) \tag{1.7}$$

For a Newtonian Liquid this is related to the tensile traction p by

$$p = \lambda f_l \tag{1.8}$$

where λ is Trouton's coefficient of viscous traction. Introducing (1.7) into (1.8) gives

$$p = \lambda \dot{l} / l \tag{1.9}$$

As said before, if the load P is constant, the traction p varies during the experiment with varying length l. Considering that the magnitude p depends upon the cross-sectional area and the latter is connected with l through the volume V of the specimen, the variation of p with l can be calculated as follows:

We may assume that the volume of the deformed material is constant* or

$$V = Al = A_o l_o \tag{1.10}$$

This makes

$$p = P / A = Pl / A_o l_o = p_o l / l_o \tag{1.11}$$

Equ. (1.9) now yields

$$p_o = \lambda \frac{l_o}{l_2} \dot{l} \tag{1.12}$$

But from (1.5)

$$\frac{l_o}{l^2} \dot{l} = D_l^S \tag{1.13}$$

and therefore by integration

* Lethersich[4] has taken into account that there may be a change of volume by assuming that Poisson's ratio differs from one half. Such a generalization can easily be effected.

$$D_l^S / p_o = t / \lambda \tag{1.14}$$

If the material is a *simple* Newtonian liquid, i.e. λ is constant and therefore independent of p_o. Equ. (1.14) represents a straight line passing through the origin with $1/\lambda$ as slope. This confirms Lethersich's method.

Lethersich applied the same method upon the large extension of a *simple Hookean* elastic solid, i.e. one in which the extensional strain* e_l^C is defined in the usual (Cauchy) way, namely by

$$e_l^C = \Delta l / l_o = l / l_o - 1 \tag{1.15}$$

This is analogous with (1.3) but now Δl is the *recoverable* elongation. Let E be Young's modulus, then in analogy with (1.8)

$$p = E\, e_l^C \tag{1.16}$$

Now from (1.11) and (1.15)

$$p_o = E D_l^S \tag{1.17}$$

where D_l^S is defined by (1.5). If $p_o = E$, (1.17) yields $D_l^S = 1$ and $l = \infty$. Equilibrium is therefore possible only if the initial traction p_o does not exceed the Young-modulus E. Introducing

$$p_o = aE \tag{1.18}$$

the factor a cannot be larger than unity.

Equ. (1.17) can also be written in the form

$$D_l^S / p_o = 1 / E \tag{1.19}$$

Therefore from (1.14) and (1.19), if we plot in a series of constant load experiments D_l^S / p_o, i.e. the Swainger extension per unit "nominal" traction (p_o) against time t, and all observations are represented by *one single curve*, this proves

(i) in the case of a viscous liquid that it is simple Newtonian

(ii) in the case of an elastic solid that it is simple Hookean.

It should be kept in mind that D^S has in our case a formal meaning only resulting from (1.11) and is of no physical significance. Lethersich regarded the method as the application of a "correction".

2. RHEOLOGICAL EQUATIONS OF THE KELVIN AND VOIGT BODIES

Lethersich did not succeed in extending this method to more complicated materials, such as the Kelvin body

$$K = N / H \tag{2.1}$$

* We distinguish between the deformation D and its recoverable part which is the strain e.

where the vertical bar indicates "parallel coupling", 'N' a (Newtonian) dashpot element and 'H' a (Hookean) spring-element. The main characteristic of this body is the "lagging" of its elastic response or its *delayed elasticity*.

In an addendum he assumed for the spring (H) element of (2.1) to follow Hooke's law in the form

$$p = E\, e_l^H \tag{2.2}$$

with the strain measured as by Hencky, namely

$$e_l^H = l_n\, (l / l_o) \tag{2.3}$$

This did not permit integration for constant load in closed form but only by means of a series-development which is not very useful. We shall presently show that integration in closed form is possible if we assume that the elastic response of the material is simple Hookean in accordance with (1.16).

Before doing so we must point out that when *large* elastic strains occur it is necessary to distinguish between the elastic strain e, the rate of strain $\dot{e}$, the flow f and the deformation D, the latter in general composed of strain and a viscous deformation.

We must accordingly distinguish between two kinds of bodies. In the first kind showing delayed elasticity we have before us a body for which the picture given by Kelvin is appropriate; namely a sponge filled with water in which the viscous resistance of the water delays the elastic response of the sponge. The rheological equation of this body can be derived by adding the partial stresses from (1.8) and (1.16) namely

$$p = E\, e_l + \lambda_f\, f_l \tag{2.4}$$

In the second kind the dissipation of energy is not due to a fluid viscosity but to a "solid" viscosity in accordance with the rheological equation postulated by Voigt

$$p = E e_l + \lambda_s\, \dot{e}_l \tag{2.5}$$

Equs. (2.4) and (2.5) give the same results when e and f are identical. This is the case either when Δl is so small that l_o can be replaced by l, or when the strain is defined by (2.3). In this case the terms "Kelvin-body" and "Voigt-body" may be used indiscriminately. If the strain is large and is defined by (1.15), only a body following (2.5) should be termed Voigt-body. This shows the limitations of rheological models in the case of large strains.

While the Voigt-body consists essentially of *one* phase, the Kelvin-body represents a two-phase system such as assumed by Pfeiffer and Saal[5] for an oxidized bitumen in which the asphaltenes form a continuous sponge-like structure, filled with the oily liquid of the maltenes.

3. THE KELVIN BODY UNDER CONSTANT LOAD

We start from (2.4) which we write

$$p = E\,(e_l^C + {}^{\tau}_{\text{ret}}\, f_l) \tag{3.1}$$

where

$$\tau_{\text{ret}} = \lambda_f / E \tag{3.2}$$

is the time of lagging or of retardation.

We now take account of (1.11), (1.7) and (1.18) and get

$$dt = \tau l_o\, dl/l\ (al - e\, l_o) \tag{3.3}$$

where we have dropped indices for simpler writing.

We shall now consider the two extreme cases when the strain is measured either in accordance with (1.15) or as proposed by Swainger namely by

$$e_i^S = \Delta l/l = 1 - l_o/l \tag{3.4}$$

Every other measure such as (2.3) is intermediate and the rheological behaviour of such "body" will also be intermediate.

3.1. If the elasticity is what may be called "simple" Hookean, Equ. (3.3) becomes

$$dt = \tau de/[e^2\,(a-1) + e\,(2a-1) + a] \tag{3.5}$$

Integration yields.

$$e/a = (e^{t/\tau} - 1)/[a + (1-a)\ e^{t/\tau}] \tag{3.6}$$

We have to distinguish the two cases that $p_o < E$ and $p_o > E$. In the first case there is a finite maximum elongation $\Delta l_{\max} = p_o/(E - p_o) \cdot l_o$) in the second case the elongation tends to ∞ at the finite time $t = \tau ln|p_o/(p_o - E)|$. Extension time curves for typical cases of 'a' are shown in Figure 1. All curves have the same tangent at the origin with the slope $1/\tau$.

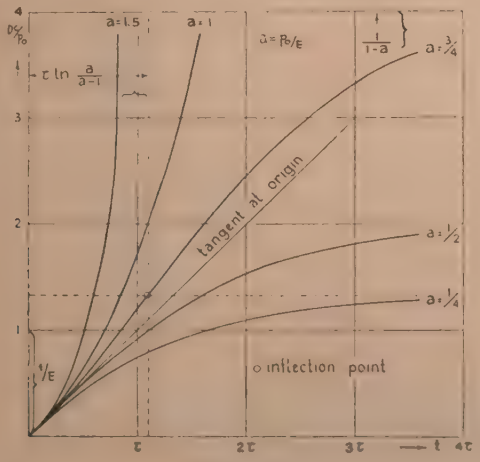


Figure 1

Cauchy strain vers. time curves of Kelvin body $e^c = \Delta l/l_0$, τ retardation time, $a = p_o/E$, p_o initial traction, E Young's modulus

Introducing e from (1.15), Equ. (3.6) becomes

$$(1 - l_o/l)/p_o = (1 - e^{t/\tau})/E \tag{3.7}$$

We may write for $1-l_o/l$ in accordance with (1.5) the symbol D_l^S. It should, however, be kept in mind that this is not the strain of the material, the latter being measured by e^C.

We find

$$D_l^S/p_o = (1 - e^{t/\tau})/E \tag{3.8}$$

The result is rather surprising, but is in keeping with Lethersich's results for the simple Hooke solid and the Newtonian liquid; namely *if we plot observations in the Swainger measure per unit nominal traction* (p_o) *against time*, all observations should lie, even for different P_o—s on *one single exponential curve* provided the elasticity is simple Hookean.

3.2. If the elasticity is related to Swainger's measure of strain (3.4) Equ. (3.3) becomes

$$dt = \tau de/(e^2 - e + a) \tag{3.9}$$

The integral will be different for the three cases $a < 1/4$) $a = 1/4$ and $a > 1/4$.

We find

3. 2. 1. $a < 1/4$

$$e/a = 2\left[e^{\sqrt{1-4a}\,t/\tau} - 1\right] \Big/ \left[\sqrt{1-4a} - 1 + (\sqrt{1-4a}+1)\,e^{\sqrt{1-4a}\,t/\tau}\right] \tag{3.10}$$

3. 2. 2. $a = 1/4$

$$e/a = 2t/(t + 2\tau) \tag{3.11}$$

3. 2. 3. $a > 1/4$

$$e/a = 2\tan\left[\frac{\sqrt{4a-1}\;t}{2\tau}\right] \Big/ \left\{\tan\left[\frac{\sqrt{4a-1}\;t}{2\tau}\right] + \sqrt{4a-1}\right\} \tag{3.12}$$

When $p_o < E/4$ there is a maximum elongation

$$\Delta l_{\max} = 2p_o l_o / [\sqrt{E2 - 4P_o E} + E] \tag{3.13}$$

when $p_o > E/4$, the elongation Δl is infinite ($e = 1$) at the finite time

$$t = 2\tau E/\sqrt{4P_o^2 - E^2}\ \text{arc tan}\left[\frac{\sqrt{4p_o^2 - E^2}}{2p_n - E}\right] \tag{3.14}$$

Extension vers. time curves for typical cases of 'a' are shown in Figure 2. Here also all curves have the same tangent at the origin with slope $1/\tau$.

It does not seem possible to find a measure of deformation D such that D/p_o should give one single curve for different p_o—s when the law of elasticity is related to the Swainger-measure e^S. However, if p_o is either so small or E so large that a can be neglected against 1, Equ. (3.10) is reduced to one identical with (3.7). This can easily

be understood. When p_o is very small or E very large, the strain is very small. But for very small strains all different measures of strain e^C, e^S, e^H and others are identical with the usual technical measure e^C.

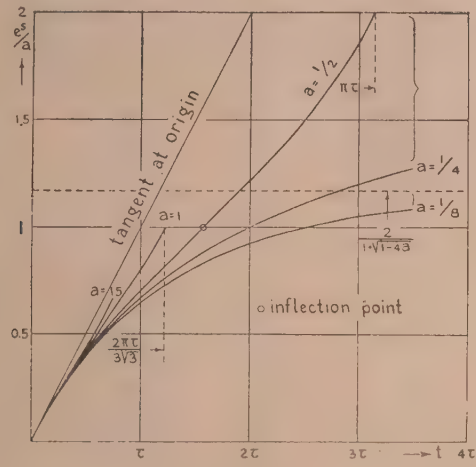


Figure 2

Swainger-strain vers, time curves of Kelvin-gel $e^S = a(1-e^{-t/\tau})$, τ retardation time, $a = p_o/E$, p_o initial traction, E Young's modulus

On the other hand let a Kelvin-body be observed in extension and plot D^C/p_o and D^S/p_o against time; if there result different curves for different p_o—s in the first and one single curve in the second case, this proves that the law of elasticity of the elastic phase of the gel is simple Hookean. This should provide a criterion by which to determine the nature of the elasticity of bitumen-gels and similar materials and to decide whether the elasticity metals, or kinetic, as of rubber is potential, as of rubber.

4. EXPERIMENTAL EXAMINATION

In order to test the present theory, a sample of bitumen supplied by the Road Research Laboratory (Harmondsworth), described as "Oxidized bitumen, 20 to 30 pen" which showed elasticity to an extraordinary degree, was subjected to a constant load in the extensometer described by Reiner[6]. The specimens consisted of prisms of square section 1 by 1 cm, so that $A_o = 1\text{cm}^2$, and of a free length of $l_o = 3.00$ cm. From a large number of experiments which were undertaken for other purposes the following five were selected:

No. of specimen	53	35	29	30	28a
Symbol	.	⊡	⊙	+	x
p_o in 10^3 dyne cm $^{-2}$	645	1140	1630	1630	2110

All experiments were carried out at a temperature of 25° C.

Details of one of the experiments (No. 53) are given in the following table:

Time minutes	Δ (Δl) cm	l cm	$\Delta l/l_o \cdot 10^2$	$\Delta l/l \cdot 10^2$	$D^C/p_o \cdot 10^7$ dyne^{-1} cm^2	$D^S/p_o \cdot 10^7$ dyne^{-1} cm^2
0	0	3.00	0.00	0.00	0.00	0.00
0.25	.05	3.05	1.67	1.64	0.26	0.254
0.5	.10	3.10	3.33	3.22	0.52	0.50
1	.15	3.15	5.00	4.76	0.78	0.745
1.5	.20	3.20	6.67	6.25	1.03	0.97
2	.25	3.25	8.33	7.70	1.29	1.19
2.5	.30	3.30	10.00	9.10	1.55	1.41
3	.35	3.35	11.67	10.45	1.81	1.61
3.5	.40	3.40	13.33	11.8	2.06	1.83
4.5	.45	3.45	15.00	13.0	2.31	2.02
5	.50	3.50	16.67	14.3	2.57	2.22
6	.55	3.55	18.3	15.5	2.84	2.40
7	.60	3.60	20.0	16.7	3.09	2.60
8.5	.65	3.65	21.7	17.8	3.34	2.76
9.5	.70	3.70	23.3	18.9	3.60	2.93
10	.75	3.75	25.0	20.0	3.86	3.10
11	.80	3.80	26.7	21.0	4.10	3.26
12	.85	3.85	28.3	22.0	4.38	3.41
13	.90	3.90	30.0	23.0	4.63	3.57
14	.95	3.95	31.7	24.0	4.90	3.72
14.5	1.00	4.00	33.3	25.0	5.15	3.87
15	1.05	4.05	35.0	25.9	5.41	4.03
15.5	1.10	4.10	36.7	26.8	5.67	4.17
16	1.15	4.15	38.3	27.7	5.95	4.30
17	1.20	4.20	40.0	28.6	6.19	4.43
17.5	1.25	4.25	41.7	29.4	6.45	4.55
18.5	1.30	4.30	43.3	30.2	6.71	4.70
19.5	1.35	4.35	45.0	31.0	7.00	4.80
20.5	1.40	4.40	46.7	31.9	7.20	4.95
21	1.45	4.45	48.3	32.6	7.50	5.05
22	1.50	4.50	50.0	33.4	7.70	5.20
23	1.55	4.55	51.7	34.0	8.00	5.27
24	1.60	4.60	53.3	34.7	8.20	5.38
25	1.65	4.65	55.0	35.4	8.50	5.50
25.5	1.70	4.70	56.7	36.1	8.75	5.60
26.5	1.75	4.75	58.3	37.0	9.05	5.75
27.5	1.80	4.80	60.0	37.6	9.30	5.82
28	1.85	4.85	61.7	38.1	9.60	5.90
29	1.90	4.90	63.3	38.7	9.85	6.00
29.5	1.95	4.95	65.0	39.4	10.10	6.10
31	2.00	5.00	66.7	40.0	10.20	6.20
			recovery			
31.5	1.65	4.65	55.0	35.4	8.50	5.50
33	1.55	4.55	51.7	34.0	8.05	5.27
34	1.35	4.35	45.0	31.0	6.96	4.80
35	1.00	4.00	33.3	25.0	5.15	3.87
60	0.90	3.90	30.0	23.0	4.63	3.57
1320	0.50	3.50	16.7	14.3	2.57	2.22

In Figure 3, D^C / p_o versus t-curves, in Figure 4, D^S / p_o versus t-curves are shown for all five experiments. The curve of Figure 4 represents with sufficient approximation all five experiments. If it is interpreted as a graph of Equ. (3.8), the following rheological constants can be determined from it:
Young's modulus of elastic phase $E = 1.331 \times 10^6$ dyne cm^{-2}
time of retardation $\tau = 372$ sec.
Trouton's coefficient of viscous traction of liquid phase $\lambda = 4.96 \times 10^8$ poises.

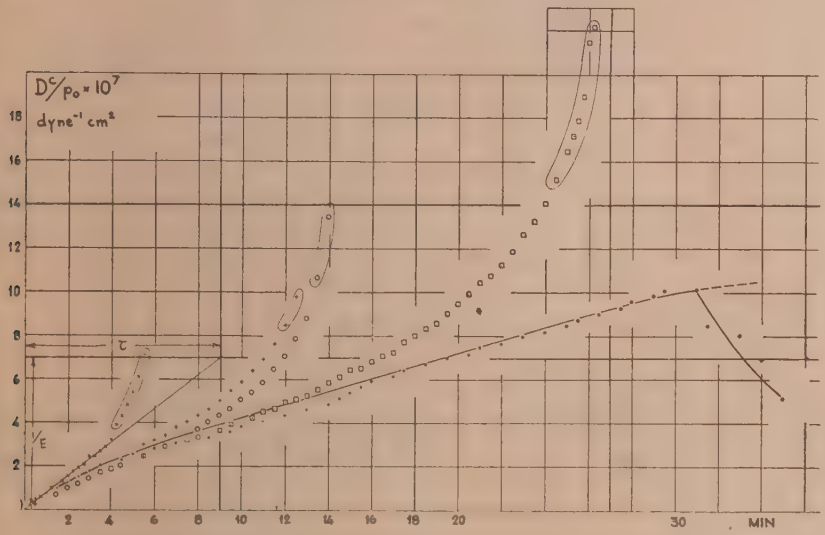


Figure 3
D^C / p_o versus t-curves

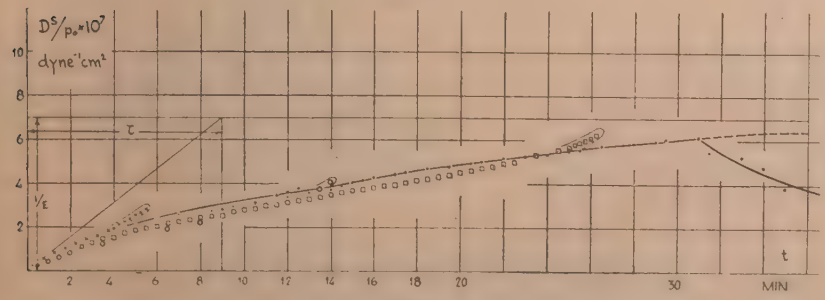


Figure 4
D^S / p_o versus t-curves

It should be kept in mind that the static modulus and the coefficient of viscosity as calculated here do not represent these constants as pertaining to the "matter" of the asphaltenes on one hand and the maltenes on the other hand, but are rather "apparent" constants as exhibited by the structure which the asphaltenes together with the maltenes form in the sample. They should be understood with the same

meaning as the "modulus of elasticity" of a helical spring as a whole in contradistinction to the modulus of the steel of which the spring is made.

However, the curve of Figure 4, while it resembles an exponential curve, is actually not one and therefore not a graph for Equ. (3.8). This is to be expected and can be explained as indicating that the bitumen is not one single K-body, but is composed of a complete *spectrum* of K-bodies, each one behaving in accordance with Equ. (3.8), but with different values of E and τ. One could assume some statistical distribution of these values and from this derive the actual curve of Figure 4. The observations were not accurate enough to permit such analysis.

As was to be expected, the specimens showed individual variations, witness the behaviour of Nos. 29 and 30 extended at the same nominal stress.

At a certain stage of the experiment the prism develops a "neck". Most of the further extension then takes place at the neck at an increasing rate until the specimen breaks. These later stages are evident in Figure 4 as "upward" bends. Sometimes cracks appear at the edges of the prism near the "caps" into which the prisms are fixed. In experiment 53 the load was removed before a neck developed and the recovery observed. This showed the characteristic "after-effect" and still continued after 24 hours.

Despite the rather crude apparatus, Figures 4 and 5

(i) confirm the theory as developed in Section 3,

(ii) support Pfeiffer and Saal's "schematic representation" of oxidized bitumen as shown in Figure 6 of the first communication,

(iii) make it probable that the elasticity of "blown" bitumen, as far as can be concluded from an extension of 66 percent, is of the "potential" and not of the "rubbery" type. This would be in agreement with the known fact[5] that the modulus of elasticity of bitumen is very little affected by temperature, and where such an effect is noticeable it is in a direction opposite to that in the case of elastomers, namely causing a *reduction* of its magnitude.

ACKNOWLEDGEMENTS

The present investigation forms part of a co-operative research between the (British) Department of Scientific and Industrial Research and the Research Council of Israel. It was carried out at the Rheological Laboratory of the Institute of Technology at Haifa and we are grateful to Prof. M. Reiner, Director of the Laboratory, for his suggestions, interest and help. It is published with the permission of the Director of the Israel Research Council.

REFERENCES

1. Andrade, E. N. da C, 1911, *Proc. Roy. Soc.*, **A84**, 1.
2. Andrade, E. N. da C and Chalmers, B., 1932, *Proc. Roy. Soc.*, **A138**, 348.
3. Lethersich, W., 1941, *Brit. Electr. Allied Ind. Res. Ass. Report*, A/T83.
4. Lethersich, W., 1944, *J. Scient. Inst.*, **21**, 27, 111.
5. Pfeiffer, J. Ph. and Saal, R. N., 1940, *J. Phys. Chem.*, **44**, 139.
6. Reiner, M., 1948. *Research on Rheological Properties of Bitumen*. Pal. Board Scient. Ind. Res. (Now Research Council of Israel), Jerusalem.
7. Reiner, M., 1951, *Bull. Res. Counc. of Israel*, **1**, No. 3,5.
8. Scott Blair, G. W., 1949, *Survey of General and Applied Rheology*, 2nd Edition, Pitman and Sons, 159.
9. Swainger, K. H., 1947, *Nature*, **160**, 399.

A TETRAHEDRAL REPRESENTATION OF THE RELATIONSHIP BETWEEN FOUR PHASES

Z. RIGBI
"Serafon" Resinous Chemicals Corporation, Rehovot

For the purposes of another paper[1], a representation in space is suggested of the following functions:

$$Br'_3 = \frac{1}{a}[H']^2\ [Br']^2$$

$$Br_2 = \frac{K}{a}[H']^2\ [Br']$$

$$HBrO = \frac{KK_h}{a}\ [H']$$

$$BrO' = \frac{KK_hK_d}{a}$$

$$\text{where } a = KK_h\ (K_d + [H'])\ +\ [H']^2\ [Br']\ ([Br'] + K)$$

and the quantities in square brackets represent molar concentrations. The ions with no brackets, represent the proportion of the oxidizing powers of these ions in the solution, and

$$Br'_3 + Br_2 + HBrO + BrO' = 100\%$$

This relation permits of the construction, within a regular tetrahedron, of a curved surface on which are ruled two sets of lines, viz., $[H']$ (or $pH = -\log [H']$) = const, and $[Br']$ = const, the distances from any point of the surface to the bounding planes representing the values of Br'_3, Br_2, etc.

In order to facilitate the plotting of the curved surface, a special instrument was constructed, in which arms at fixed angles of 157° one from the other were arranged so that the length of the arms could be varied in accordance with the required value of the variables.

This extension to the widespread triangular chart should have considerable applications in a number of fields of physical chemistry, metallurgy, etc. However, while the use of the tetrahedron is likely to give a valuable pictorial representation of the function, its preparation is somewhat labourious and an equally accurate representation may be obtained by the projection of the ruled surfaces on one of the bounding planes of the tetrahedron, together with the projection of the lines of constant height from the plane of reference.

In the attached drawing (Figure 1), only the projection of the ruled constant pH and $[Br']$ lines, and not the projection of the lines of constant BrO', have been plotted as the particular and possibly exceptional distribution of these lines would easily cause errors in the use of the diagram. Instead, an auxiliary diagram showing

Received, June 1952.

the value of BrO′ for each value of pH and [Br′] has been plotted. The use of the two diagrams in conjunction allows the values of all the other variables to be determined if any two are known. However, it must be remembered that it will be necessary to reduce the values of Br_3', Br_2, and HBrO read off the triangular chart $\frac{BrO'}{3}$, in view of the geometry of the tetrahedron.

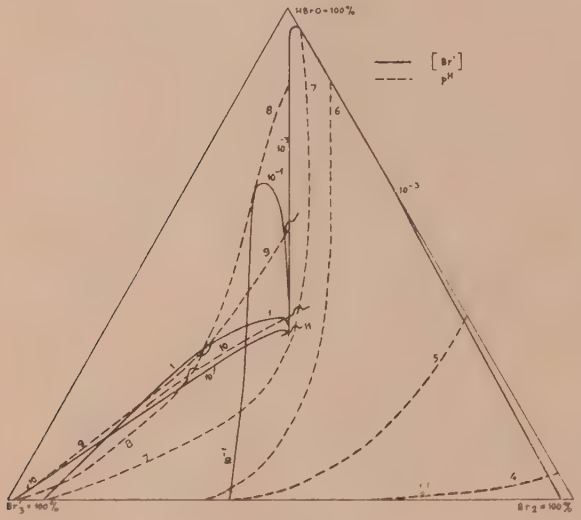


Figure 1

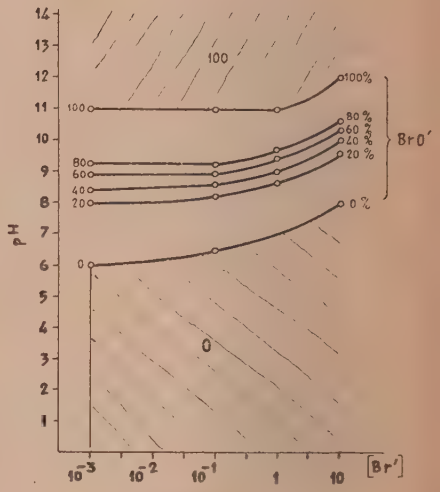


Figure 2

Thus, for example, at [Br′] = 0.1, and pH = 9, BrO′ ~ 60% (from Figure 2) and from Figure 1, $Br_3 \sim 24 - \frac{60}{3} \simeq 4$, $Br_2 \simeq 22 - \frac{60}{3} = 2$, $HBrO = 54 - \frac{60}{3} = 34$.

The assistance of Mr. H. Tabor, of the National Physical Laboratory of Israel in constructing the instrument refessed to is gratafully acknowleged.

REFERENCE

1. LEWIN, M., 1952, *Bull. Res. Counc. of Israel*, **2**, 101.

THE COMPOSITION OF HYPOBROMITE SOLUTIONS AT VARIOUS pH VALUES AND BROMIDE CONCENTRATIONS*

MENACHEM LEWIN
Research Council of Israel

In connection with an extended research programme on the industrial utilization of bromine, one of the main products of the Dead Sea, investigations of the oxidizing and brominating reaction of hypobromite solutions have been conducted. In the following, some of the conclusions reached in the course of these investigations are presented.

The oxidizing activity of hypobromite solutions is known to depend largely on the active oxidizing agent present in solution under the conditions of the experiment. For instance, on oxidizing cellulose by hypobromite[1] at a neutral pH, mainly reducing groups are formed, whereas on oxidizing at strongly alkaline pH, carboxyl-groups are formed. Similar results are noted also in the case of oxidation of alcohols[2]. This difference in action is explained by the fact that at the neutral pH values the oxidizing solution is composed mainly of hypobromous acid, in contra-distinction to the alkaline pH range where the main component is the hypobromite ion.

The decomposition of hypobromite[3], bromite[4] and hypochlorite-hypobromite solutions[5] are further examples of reactions influenced by the pH. The influence of the bromide concentration and indirectly the initial concentration of the hypobromite is to a certain extent similar to that of the pH.

In view of the fact that both (H^+) and (Br^-) concentrations profoundly influence the composition of the bromide solutions, and as the above examples show, this composition in turn influences reaction rates and paths, we decided to calculate and plot in convenient form the composition of hypobromite solutions for various values of (H^+) and (Br^-) in order to facilitate the study and treatment of reactions involving bromine solutions.

The composition of hypobromite solutions is governed by 3 equilibria:

$$(H^+)\,(BrO^-) \rightleftarrows Kd\,(HBrO) \qquad (1)$$

$$(H^+)\,(Br^-)\,(HBrO) \rightleftarrows Kh\,(Br_2) \qquad (2)$$

$$(Br^-)\,(Br_2) \rightleftarrows K\,(Br_3^-) \qquad (3)$$

which are rapidly established. The hypobromite solutions are therefore composed of 4 oxidizing agents:

$$Ox = (BrO^-) + (HBrO) + (Br_2) + (Br_3^-) \qquad (4)$$

The concentrations of these components may be determined by solving the above equations, assuming constant (H^+) and (Br^-):

*Received June 1952

$$a\,(Br^-_3) = (H^+)^2 \quad (Br^-)^2 \;.\; Ox \tag{5}$$
$$a\,(Br_2) = K(H^+)^2\,(Br^-) \;.\; Ox \tag{6}$$
$$a\,(HBrO) = K\,Kh \quad (H^+) \;.\; Ox \tag{7}$$
$$a\,(BrO^-) = K\,Kh\,Kd \;.\; Ox \tag{8}$$
$$a = K\,Kh\,[Kd + (H^+)] + (H^+)^2\,(Br^-)\,[(Br^-) + K] \tag{9}$$

With the aid of equations 5–9 the composition of the hypobromide solutions over the whole pH range 0–14 and bromide concentrations 0–10 moles per liter have been calculated, using the equilibrium constants: $K = 0.063$[6], $Kh = 5.8\times10^{-9}$ [7] and $Kd = 2\times10^{-9}$ [8,9] The results of the calculation are summarized in Figures 1–8, and have been collated into one 3-dimensional diagram according to a method described by Rigbi[10]. A photograph of this diagram is given (Figure 11).

It is seen that at low bromide concentrations of $0–10^{-6}$ moles per liter, the main components of the solution are HBrO and BrO^-. In water disinfection processes[11], usually carried out at these concentrations within the limits of pH 5–9, there will be almost no action of elementary bromine, hypobromous acid being the oxidizing agent.

At higher bromide concentrations the elementary bromide appears at higher pH values and at a concentration of 10^{-3} at pH = 5 it reaches ~ 50% of the oxidative capacity of the solution. The bromide concentration range 10^{-2}—10^{-4} is especially important for the bleaching processes with hypobromite and hypochlorite-bromide solutions. At pH = 6.5 — 7.5, at which the bleaching reactions are usually carried out, mainly hypobromous acid and elementary bromide will be present in the solution.

The actual concentration of Br_2 and Br^- in the solutions of hypobromite depends on the method of preparation of these solutions. There are two methods for preparing hypobromite solutions:

a. The classical method of dissolving bromine in alkali:

$$Br_2 + 2NaOH = NaOBr + NaBr \tag{10}$$

Immediately after preparation, these solutions contain bromide ions in an amount equal to half the total bromide present. During an oxidation reaction the concentration of the bromide ions and subsequently of elementary bromine will gradually increase due to the reduction of HBrO or BrO^- and equilibrium (2), respectively.

b. Oxidation of bromide by hypochlorite[12]:

$$NaOCl + Br^- = NaOBr + Cl^- \tag{11}$$

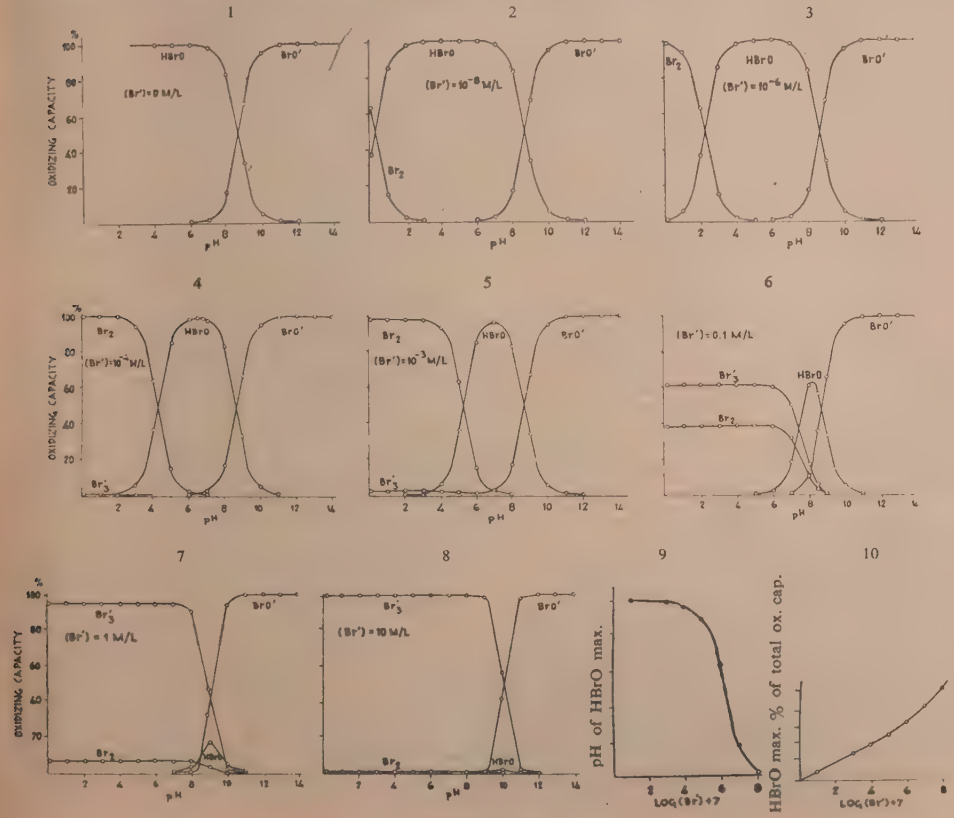
The initial solution prepared by this method is virtually free of bromide and its composition is given by Figures 1 and 2. With the progress of an oxidation reaction the concentration of bromide will steadily increase and only after 50% of the hypobromite solution is reduced will the concentration of bromide equal half the total bromine concentration. It can easily be calculated that for the same initial concentration of total bromine, the solution prepared according to method (b) will always contain less than half the bromide ions present in a solution prepared according to method (a). As the rate of decomposition of hypobromite solutions increases with

the increase in the bromide concentration, solutions (b) will be more stable than solutions (a) at the same pH values.

At bromide concentrations above 10^{-2} moles per liter the composition of the hypobromite solutions at the neutral and acidic pH values changes significantly. The pH range of HOBr presence and the percentage HOBr of the total oxidizing capacity both diminish with increase in Br^- concentration as deduced from Figures 9 and 10. At the same time the concentration of Br^-_3 increases. This range of high bromide concentration is characteristic of oxidations of a preparative nature usually carried out at a high concentration of bromine or hypobromite.

In the alkaline pH range 10—14 the bromide concentration has very little influence and the hypobromite ions are almost the sole oxidizing component of the solution.

The concentration of bromide in hypobromite solutions is generally limited by the total oxidizing capacity and usually does not exceed 50% of the total bromine present. However, by addition of bromides, the composition of the solutions and the nature of their oxidizing activity can be easily changed.



Figures 1—10

Plots of compositions of hypobromite solutions of various pH values and bromide concentrations

ACKNOWLEDGEMENTS

The author is grateful to Dr. R. Bloch of the Palestine Potash Ltd. and Dr. B. Perlmutter of the Dept. of Physical Chemistry, Hebrew University, for useful discussions and to Mr. Rosendorf for the construction of the 3-dimensional diagram.

REFERENCES

1. Lewin, M., 1947, Ph. D. Thesis, Jerusalem.
5. Perlmutter, B., 1947, Ph. D. Thesis, Jerusalem.
3. Engel, P., 1951, M. Sc .Thesis, Jerusalem; Chapin, R. M., 1934, *J. Am. Chem. Soc.*, **56**, 2211.
4. Oplatka, A., 1951, M. Sc. Thesis, Jerusalem.
5. Lewin, M., Unpublished results.
6. Griffith, McKeown and Winn. 1932, *Trans. Faraday Soc.* **28** 101.
7. Liebhaftsky, H., 1934, *J. Am. Chem. Soc.* **56**, 1500.
8. Shilow, E., 1938, *ibid.*, **60**, 490.
9. Farkas, L. and Lewin, M., 99. *ibid.*, **72**, 5766.
10. Rigbi, Z., 1952, *Bull. Res. Counc. of Israel*, **2**, 1950.
11. Farkas, H., Unpublished results,
12. Farkas, L., Lewin, M., and Bloch, R., 1949, *J. Am. Chem. Soc.*, **71**, 1988.

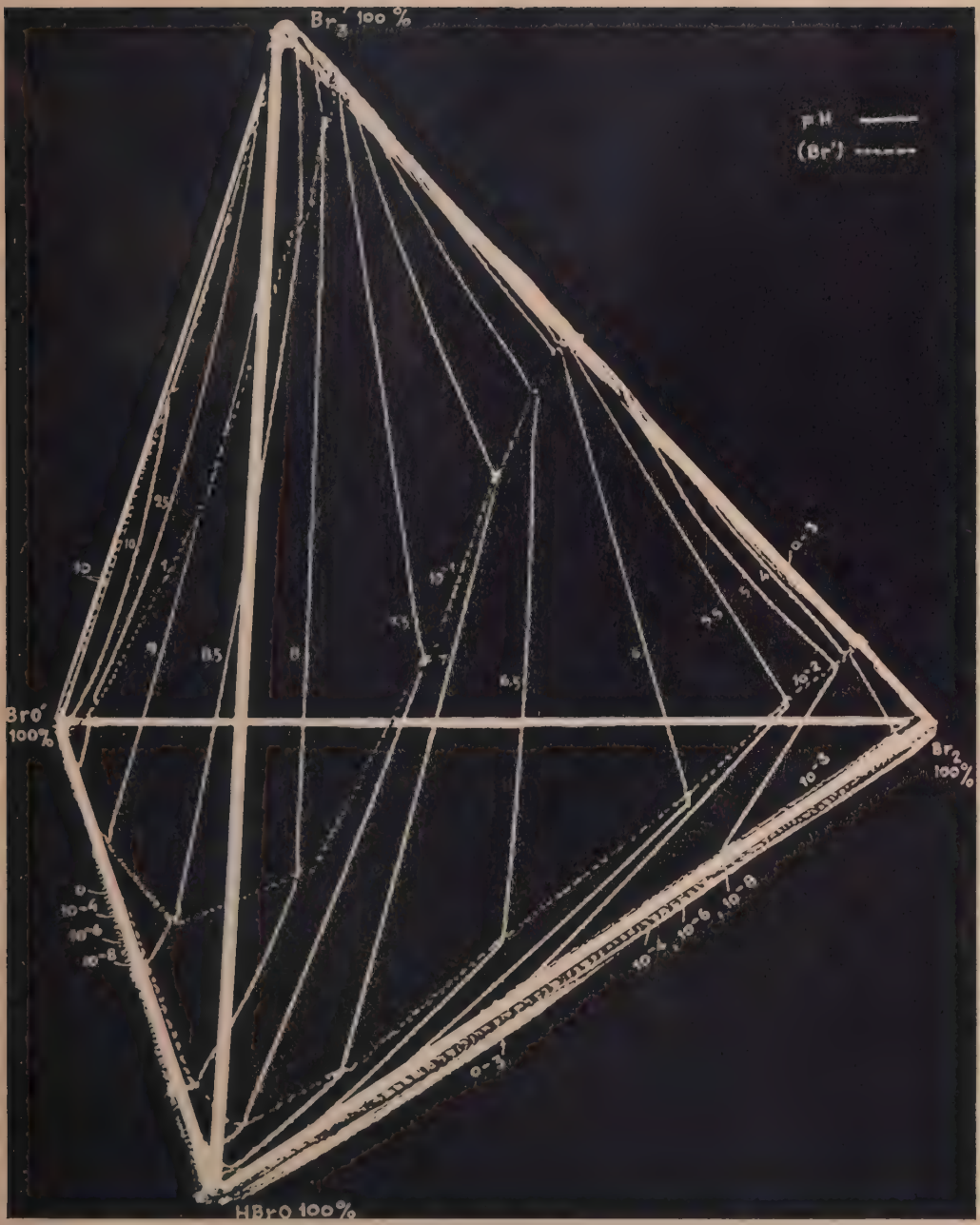


Figure 11

Photograph of 3-dimensional diagram representing the composition of hypobromite solutions.

DETERMINATION OF RbCl IN RUBIDIUM ENRICHED DEAD SEA CARNALLITES*

A. Halperin and S. Sambursky
Physics Department, The Hebrew University, Jerusalem

INTRODUCTION

This work was undertaken in connection with a programme of the Palestine Potash Ltd. to extract rubidium from the Dead Sea Salts. Work done in accordance with the first part of this programme, consisted in the examination for their rubidium content, of samples of salts taken directly from the Dead Sea itself, and at the various stages of the potash extraction process. The spectroscopical methods used for these determinations and some of the results obtained, are described in detail in paper I[1].

In the process of the potash extraction, carnallite is separated at a certain stage of evaporation of the Dead Sea water. This carnallite, which we call primary carnallite and denote by CI, was found to undergo a three fold enrichment in the concentration of rubidium, which amounts to 0.02% of RbCl, whereas the natural salt of the Dead Sea contains only about 0.007%.

Although other salts obtained in the potash factories contained more RbCl (up to 0.03%), the carnallite was chosen as a starting point for further extraction of rubidium, as methods for such extraction are known and used in carnallite mines in other parts of the world[2,3]. These methods may be affected by even slight variations in the composition of the natural carnallite. It is known, for example, that small quantities of ammonia adversely affect the efficiency of extraction[2]. It was considered necessary therefore to make a careful investigation of the application of the method to the Dead Sea salts.

In this paper, a description of some of the stages of extraction. and spectroscopical methods used to determine the amount of the RbCl in the enriched carnallites is given.

THE PROCESS OF EXTRACTION OF RUBIDIUM

The method is that of fractional recrystallization. It is based on the fact that when carnallite is dissolved in water, at first no carnallite is deposited by evaporation. This is in accord with the well-known phase diagram [1,4] of the system $KCl-MgCl_2-NaCl-H_2O$ of the naturai carnallite which contains a few prcent of NaCl and also small quantities of other salts in addition to the $MgCl_2-H_2O$ system of the chemical car-

* Received July 1952.

** This work represents part of a dissertation submitted by A. Halperin to the Seante of the Hebrew University, Jerusalem, in fulfillment of the requirements for the degree of Doctor of Philosophy. Another part of this dissertation, which will be referred to here as paper I, was published in the July 1952 issue of the *J. Opt. Soc. Am.*

nallite. First only NaCl and KCl are deposited from the solution until the so called "carnallite point" is reached, when deposition of carnallite begins. Deposition of the carnallite continues until another point in the phase diagram is reached, at which the mother liquor contains almost pure $MgCl_2$. The specific gravity of the mother-liquor was used to provide an indication of the two points between which the carnallite crystallizes, and was found to be 1.275 at the beginning of deposition, and about 1.32 at the end point.

The carnallite obtained in this process from primary carnallite, called secondary carnallite (CII) is only about one sixth in weight of the original primary carnallite; it was found, however, that about half the RbCl from the original CI was concentrated in it, so that a threefold enrichment in concentration of RbCl was obtained. (This is essentially what occurs when CI is deposited from the Dead Sea water, except that in that first step the composition of the salts is more complex, and many other salts such as $CaCl_2$, $SrCl_2$, etc. which are also present in the mother liquor alter the points between which the carnallite is deposited in this case).

The process may then be repeated starting with CII to obtain CIII, which is further enriched in rubidium, and so on.

In this method no chemical reagents are needed, and so it has great economical advantage compared with chemical methods in which expensive reagents are needed.

SPECTROSCOPIC METHODS

The samples under examination in this work were all of the same basic composition namely carnallites, and therefore effects of extraneous elements need not be considered and the usual method of "Internal standards" may be used (see paper I). As rapid determinations are essential in industrial extraction of rubidium, a part of this work was devoted to developing a direct reading spectrophotometer suitable for this purpose. This apparatus is described below and results of analyses by this spectrophotometer are compared with those obtained by photographic methods.

With some exceptions which are mentioned below, the technique was the same as in paper I, where the type of spectrograph used, the light source, conditions of excitation, and the handling of the samples are described. When photographic methods were used, the type of plates, the plate processing and density measurements were also as in paper I.

Photographic methods

At first the potassium resonance line, K7699A was chosen as reference line and the line Rb7800A as analysis line. This reference line has some advantages: it is located near the analysis line on the photographic plate, it has very nearly the same excitation potential, and the boiling points of the chlorides of potassium and rubidium differ but slightly. In addition, potassium is present in nearly the same concentration in all the carnallites which had to be analysed and so the sample is ready for arcing without introducing the internal standard into it. Since as compared with concentrations of the RbCl in the samples, the concentration of KCl in the carnallite was too high to give suitable densities on the photographic plates, its density on the

photographic plate was reduced relative to that of the rubidium line by putting a double layer of the Wratten Gelatine Filter No. 87 before the slit of the spectrograph.

But there are also some disadvantages in using this reference line. First, the concentration of the KCl varies slightly from sample to sample, and for accurate analyses one should take it into account. Secondly, the high self-absorption in the potassium reference line makes the intensity of this line liable to large variations which impair the accuracy of the analysis. The standard deviation obtained from 30 analyses by this method, of samples containing RbCl of concentrations from 0.1—1 %, was found to be 13 % of the amount present.

When using the line Rb 7948A as analysis line, the accuracy was still lower, probably because the difference in self-absorption between the analysis line and the reference line is larger in this case.

Analysis by Measuring the Width of Lines[5,6] This method differs from the usual photographic method only in the way in which intensities of the analysis and reference lines are compared. Here, instead of comparing the peak densities of the two lines, we measure the width of the reference line at the point at which its density is equal to the peak density of the analysis line. In the few cases, where this method was used, improvement in accuracy is claimed[7,8]. Improvements may be expected especially when using self-absorbing lines, as variations in self-absorption affect the peaks of the lines most. So, the microphotometer records of the above mentioned 30 determinations were examined also by this method. In practice the width of the line was measured on the microphotometer records obtained with the drum carrying the recording paper of the Moll microphotometer adjusted to a high speed, so that the width of the line as it appeared on the recording paper was 3—6 mm and was measured easily. The working curve for determination of RbCl by this method is

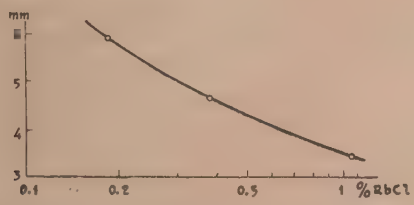


Figure 1
Working curve for determination of RbCl by the method of measuring the lioe width

given in Figure 1. The standard deviation obtained from the 30 determinations was 10 % of the amount present. Besides the improvement in accuracy, time is also saved by this method, as density curves are not needed, and only one spectrum is recorded by the microphotometer for each determination, from which the line width is directly measured.

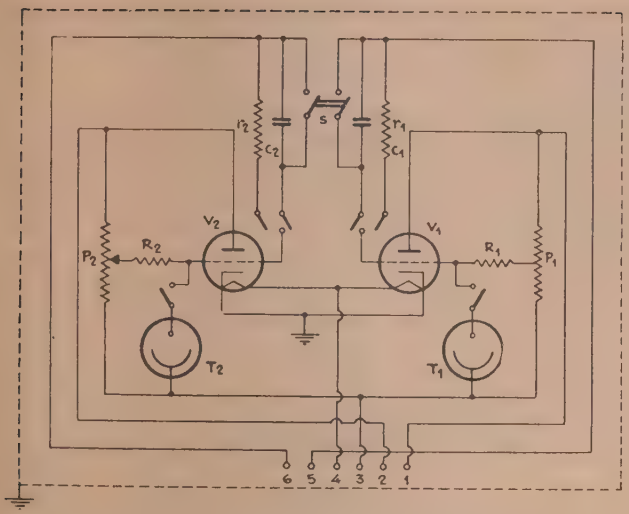
The Cs 8521A as reference line The caesium has to be added to the samples. This was done by preparing a standard mixture of 1 % CsCl in pure NaCl, and each of the samples was diluted with equal weight of this standard mixture. The density of the reference line was suitable for determination of rubidium in the concentration range 0.1—3 %. From a series of analyses carried out on prepared standard samples with

known concentrations of RbCl, by the usual photographic methods, the standard deviation was found to be about 8%, with the Rb7948A as analysis line. In this case this line gave better accuracy than the Rb7800A.

The Direct Reading Spectrophotometer

Description of the Apparatus Such an apparatus has to fullfil the following two conditions: First, it should be possible to measure simultaneously the intensities of both the analysis and the reference lines. This is necessary as with the arc used as light-source, the intensities of the spectral lines are liable to vary with time. Secondly, as the ratio of intensities of the two lines may also vary momentarily, the average of this ratio during a certain period should be taken, which means that the apparatus should be of the integrating type, (which is the case when photographic methods are used). In order to fullfil both the requirements, the following apparatus was built: two phototubes served as the light- sensitive device, and two small capacitors, connected one to each of the phototubes, served as the integrators for the photo-currents developed by the radiation of the respective spectral lines. A brass plate was attached to the camera of a Hilger Constant Deviation Spectrometer in place of the photographic plate. Two slits, 0.2 mm wide, 15mm high and parallel to the spectral line, were fitted to this plate, one of them fixed and the other movable along the plate by a micrometer screw. By turning the wavelength drum of the spectrometer one of the spectral lines to be measured was adjusted to pass the fixed slit, while the movable slit was adjusted so that the other line used passed through it. The small mirrors attached one to each of the slits, deviated the spectral lines to direct them to vacuum phototubes of the type CEVll. These phototubes have their peak of sensitivity at about 8000A, the region suitable for the spectral lines we use, and their anodes are well-insulated from the cathodes, so that after cleaning the envelopes round the anodes and covering with paraffin, the internal resistance of the tubes in darkness was found to exceed 10^{14} ohms. In order that the measurements made be of the integrating type, the photocurrent of each tube was fed into a small, well insulated, mica capacitor of 2000 pF. The charge of each of the capacitors, which give the relative intensity of the suitable spectral line, was measured by suitable electrometer tube circuits. A schematic diagram of the apparatus is given in Figure 2.

In the upper half of this figure the circuit of the phototubes and the electrometer tubes is given. This part was enclosed in a small light tight iron box attached to the camera of the spectrograph. It is connected to the rest of the apparatus, the control and power supply box, by means of a screened cable. T_1, T_2 are the two phototubes, and C_1, C_2 the integrating capacitors, r_1, r_2 are high resistances of the order of 10^9 ohms which serve for test purposes, and are usually disconnected from the phototubes. V_1, V_2 are simple triodes of type E1171 which serve as electrometer tubes. For this purpose the tubes are operated under suitable conditions to ensure low grid currents. For further insulation the envelopes of the tubes are paraffined around the grid caps. These tubes were chosen from a large number investigated as under suitable operating conditions (the heating current was reduced to 150 milliamp. and the plate voltage to 15—20 volts), their grid currents were lower than $3{:}10^{-13}$ amp. This was reduced to less than $1{:}10^{-13}$ amp by the compensating currents fed to the grids



T_1, T_2 — CE V 11
V_1, V_2 — E1171
C_1, C_2 — 2000pF
r_1, r_2 — 10^9 - 10^{10} Ohms
R_1, R_2 — $5 \cdot 10^{13}$ ”
P_1, P_2 — $6 \cdot 10^7$ ”
P_3, P_4 — 100 ”
P_5, P_6 — $2 \cdot 10^4$ ”
R_4 — 100 ”
R_5 — 120 ”
R_6 — 50 ”
R_7 — $2 \cdot 10^4$ ”
R_8 — $4.5 \cdot 10^4$ ”
R_9 — $4.5 \cdot 10^5$ ”
B_1 — 8 volts
B_2 — 22.5 ”
B_3 — 22.5 ”

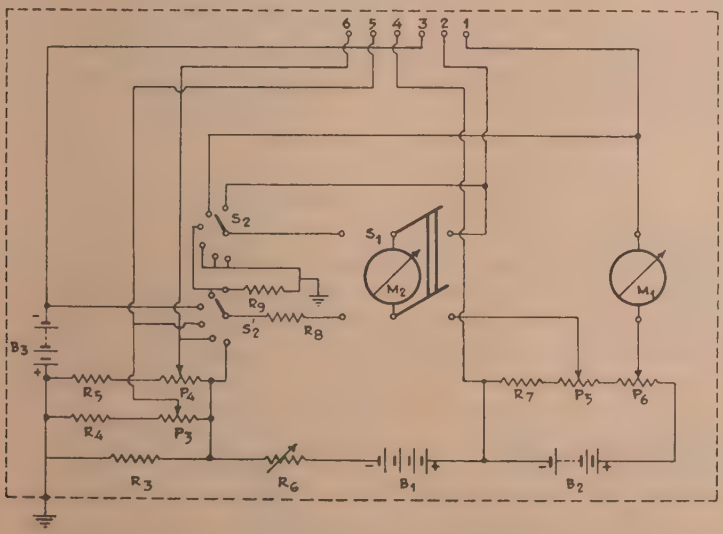


Figure 2
The electronic circuit of the direct reading spectrophotometer

by the voltage dividers P_1, P_2 and the high resistors (higher than 10^{13} ohms) R_1, R_2. Under these conditions the transconductance of the tubes was about 50 microamp per volt for plate currents of about 35 microamp.

In the lower part of Figure 2, the powerpack and the measurement and control devices are shown. Values of resistors, voltages etc. are given with the figure, and some notes will be given here.

The grid bias is supplied from the heating circuit. This improves stability as reduction in the voltage of the heating batteries (B_1) is accompanied with reduction of the negative grid bias, and thus the plate current is kept nearly constant.

S_1 is a double pole double through switch which serves to disconnect the microammeter M_2 from the plate circuit of the electro-meter tube V_2, and connect it to the control circuit. In this circuit, M_2 is used as a voltmeter, by which the voltages appearing in the circuit are measured. For this purpose, the six positions of the rotatory switch S_2—S'_2 are used. In the first, second and third positions of S_2—S'_2, the full range of the voltmeter is 2.5 volts. It measures the voltage across R_3 (which is a measure of the heating current) in the first position, the bias on the grid of V_2 in the second, and that on the grid of V_1 in the third. In the founth position, the voltage on the phototube (supplied by B_3) is measured, and in the fifth and sixth positions, the plate voltages of V_2 and V_1 respectively.

Adjustment and operation The entrance slit of the spectrometer was opened to 0.08 mm and the exit slits to 0.20. Thus adjustment of the spectral lines to the exit slits was not critical.

Immediately after the apparatus is switched on, the supply voltages are measured and adjusted to the predetermined values by means of the control circuit. About 15 minutes later equilibrium in the operating conditions of the tubes is reached, and now the grid currents are compensated by adjusting P_1, P_2 (Figure 2) to values below $1:10^{-13}$ amp. The biases of the tubes V_1, V_2 are then adjusted to make the microammeters M_1, M_2 to read 35 and 34 microamp respectively. These points correspond approximately to zero grid current of the two tubes, so they were chosen as starting points.

In the first operation, adjustment of the spectral lines to the exit slit was of course necessary, as was also the adjustment of the focus of the spectrometer to the plane of the exit slits and the direction of the small mirrors so that the spectral lines fall upon the cathods of the phototubes. The two lines used were Rb7948A as analysis line and Cs8521A as reference line. Preparation of the samples was the same as in the corresponding case of the photographic determinations. After suitable pre burning time of the arc the double switch S (Figure 2) is opened, and charging of the integrating capacitors C_1, C_2 begins. An integrating time of 50—60 seconds seems to be suitable, but instead of keeping constant the time of exposure, it is more convenient to keep constant the charge obtained on C_1 by the integrated photocurrent stored in it due to the reference line Cs8521A. This charge is obtained from the reading on the microammeter M_1, in the plate circuit of the electrometer-tube V_1.

After an exposure of about 60 sec, the voltage across C_1 was found to be 0.18 volts, which corresponds to reduction in the plate current (read on M_1) from 35 to 17 microamp. If we stop the exposure, by shutting the entrance slit, exactly at this point, the reading on M_2, which is a function of the photocurrent due to the rubidium analysis line is dependent on the concentration of rubidium in the sample under examination. A working curve obtained from a series of prepared samples is given in Figure 3. In the ordinate, I_t is the reading on M_2 at the moment the exposure is stopped (when M_1, reads 17 micramp.).

As the characteristics of the tube vary with time, it was necessary to make periodic

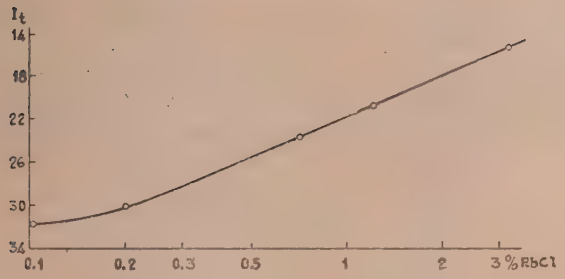


Figure 3
Working curve for determination of RbCl by the direct reading method

calibrations. For the tube V_1, it was already mentioned above, that reduction in the plate current from 35 to 17 microamp corresonds to 0.18 volts across C_1. For the tube V_2 it was found that reduction in the plate current from 34 to 15 microamp corresponds to 0.31 volts across C_2. A suitable correction factor should be applied whenever this ratio changes. In fact only a small correction was necessary when repeating measurements after a time interval of 3 months. From a series of 35 determinations carried out with this apparatus, on prepared samples containing known concentrations of RbCl, the standard deviation was found to be 5.4% of the amount present, for concentrations of 0.1—3% of RbCl. For higher concentrations the accuracy is lower, as the self absorption of the spectral lines in the light-source reaches too high a value.

COMPARISON OF THE METHODS

In the following table, the accuracy obtained and the time needed for a determination (not including time taken for preparation of samples) by the different methods described above are given for comparison. From the table we see that by the direct reading method not only time is saved, but the accuracy is also improved in comparison with the photographic method using the same reference line.

TABLE I

Method Used	Reference line	Standard deviation in %	Time needed for one determination (in min.)
Direct reading	Cs 8521	5.4	5
Usual photographic	Cs 8521	8.3	40
Usual photographic	K 7699	13	40
Line width	K 7699	10	20

The improved accuracy obtained by the line width method compared with the usual photographic method is remarkable, especially as it is also quicker. The accuracy of the line width method with Cs8521A as reference line was not checked, but it seems probable that improvement in accuracy will be obtained in this case also.

Since the principal source of error in all the determinations is due to fluctuations in the light source, which are specially pronounced when using self absorbing spectral lines, better accuracy might be obtained if a more stable light source were used.

RESULTS ON DETERMINATIONS OF RbCl IN ENRICHED CARNALLITES

Starting with 10 kg of secondary carnallite (CII), prepared in the Palestine Potash Ltd. plants at the Dead Sea, CIII, CIV, and CV were obtained in our laboratories by the process described above. The concentrations of RbCl in these carnallites are given below:

TABLE II

Carnallite	%RbCl
CI	0.02
CII	0.045
CIII	0.14
CIV	0.47
CV	0.52

From the results we see that the process of enrichment in rubidium concentration continues up to CIV where, presumably, interference by ammonia begins. It would be desirable to find a way to overcome this difficulty by improving the process of fractional recrystallization without the necessity of evaporating the ammonia by heating, which is not economical.

Further research is necessary in order to make the process more efficient. In the simple process of extraction which is described above, about half of the rubidium is lost in each stage. Part of this remains in the separated KCl and part in the mother liquor. It is possible to recover it by producing new carnallites by combinations of the KCl with the mother liquor at a suitable stage, or by adding the components to carnallites precipitated in lower stages poorer in their rubidium content.

Work was begun in this direction, but was stopped in 1948 with the severance of connections with the plants at the North of the Dead Sea.

ACKNOWLEDGMENT

We should like to mention the important part taken in this work by Dr. G. Wolfsohn until his untimely death.*

Finally we should like to express our appreciatien for the aid rendered by the Palestine Potash Ltd. and especially to Dr. M. R. Bloch for his continued interest and valuable advice.

REFERENCES

1. See footnote, p. 1.
2. D'Ans, J., 1933, *Angew. Chem.*, **46**, 491.
   D'Ans, J. and Busch, F., 1937, *Anorg. Chem.*, **232**, 337.
3. Bursker, E. S. and Feldman, P. V., *Kalii USSR*, **4**, 21.
4. *Int. Crit. Tables* IV, p. 310-311.
5. Gerlach, W. and Rollwagen, W., 1937, *Naturwis.*, **25**, 570.
6. Eisonlohr, F. and Alexy, K., 1937, *Z. Phys. Chem.*, **179**, 241.
7. Coheur, P., 1946, *J. Opt. Soc. Am.*, **36**, 498.
8. Eastmond, E. Y. and Williams, B. E. 1948, *J. Opt. Soc. Am.*, **38**, 800.

* Dr. Wolfsohn was killed on his way to the University laboratories on Mount Scopus on April 1948.

SOME OBSERVATIONS ON THE DECOMPOSITION OF CARNALLITE

R. Bloch
Palestine Potash, Ltd.

Vera Kertes and D. Lowy
Research Council of Israel

The double salt, carnallite, $KCl \cdot MgCl_2 \cdot 6H_2O$, is one of the ores from which Potash is made. It occurs in nature, together with sylvinite (a mixture of NaCl and KCl) and with common salt in massive formations. It is one of the salts obtained by evaporation of ocean water[1], and is the potash-bearing compound crystallising from Dead Sea Brine.

In order to derive commercial "Muriate of Potash" (KCl) from carnallite, it may be treated with water or brine in such a way that its $MgCl_2$ goes into solution while KCl is yielded in solid form. This treatment of carnallite, industrially called 'decomposition of carnallite', in spite of the misleading connotations of the term is one of the basic steps in making "Muriate of Potash" according to the process used at the Dead Sea works. It appears possible, and is definitely desirable to control the purity and particle-size of the resulting potassium chloride by careful definition of the conditions of decomposition. It was therefore desired to investigate the detailed mechanism of the reaction.

The phase diagram[2] of the system $MgCl_2$—KCl—H_2O (Figure 1) shows that by addition of carnallite to water, solutions are formed in which the ratio $Mg^{++} : K_2^{++}$

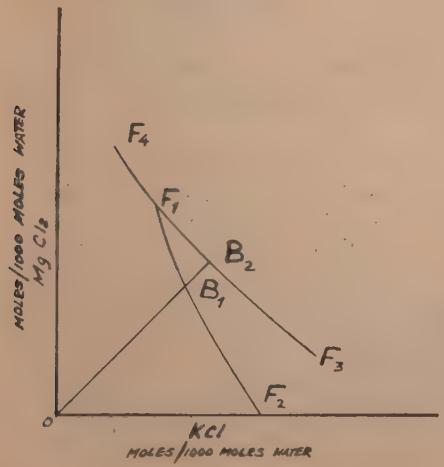


Figure 1
Phase diagram of the system $MgCl_2$-KCl-H_2O

* Received July 1952.

$= 1 : 1/2$ up to and until the point B_1 on F_1F_2. F_1F_2 represents solutions saturated with respect to KCl. Addition of carnallite to solution B_1 must give magnesium-richer solutions and precipitates of KCl.

With the aid of the microscope it is possible to see in detail what happens during this process. Carnallite crystals placed in a drop of water between two slides dissolve, becoming rounded at the edges and corners finally vanishing. In the proximate locality of the dissolving carnallite, KCl begins to precipitate in clean and square or cubic crystals, growing (with increasing imperfection) to cubic or cuboid tablets of skeletal structure. When small, they may be observed to drift away from the parent carnallite crystal growing as they drift, and eventually to adhere to the slide.

If instead of water, a brine consisting of KCl-carnallite invariant solution together with a small proportion of water (1 : 20 or 1 : 40) is used, the decomposition occurs more slowly, the crystals formed are more compact and less dendritic, and the crystals tend less to grow in clusters.

If carnallite is placed in water on a watch-glass together with some suspended particles, the form of generated convection currents may be observed. A current converges above the carnallite and flows away below it. Over the points where KCl-deposition occurs the solution rises (Figure 2).

Figure 2
Convection currents over a carnallite crystal in a watch glass.

It is to be noted that there is a convective flow of solution from carnallite to KCl which, thermal effects apart, is supersaturated with respect to KCl.

It is apparent that solution flows down the surface of the carnallite crystal owing to increase in density consequent upon dissolution. Conversely it rises from the growing KCl crystals because of decrease in density consequent on precipitation of KCl.

The density-changes are due not only to the increased and decreased salt-content, but also to the relevant heats of dissolution and of crystallisation[3,4].

The solution flowing down the carnallite must constitute a flowing-film, of the type described by Bloch[5] for NaCl crystals and examined from a theoretical viewpoint by Reiner[6].

So long as KCl is not precipitated from the supersaturated solution its constitution is independent of the KCl-saturation line, F_1F_2, and is limited only by the carnallite-saturation line, F_1F_3, obtained by extrapolation of the stable carnalite-saturation curve, F_1F_4. It may be observed that KCl precipitated by carnallite crystallises at some microscopic distance from the carnallite : the solution between the growing KCl and the dissolving carnallite must be supersaturated with respect to KCl — i.e. to lie between curves F_1F_2, F_1F_3 or on the latter curve. It is a reasonable supposition, but by no means certain, that the solution actually in contact with the carnallite are saturated with respect to it, while those from which KCl precipitates are mixtures of this with solution from the bulk of brine in proportions depending on the effectiveness of stirring — which in turn depends on the facility of nucleation of KCl.

The fact that KCl is never observed to crystallise in contact with the parent carnallite suggests that either in the immediate vicinity of the carnallite the solution is stabilised by the presence of the carnallite, or that an appreciable time is always required before a supersaturated solution of KCl can nucleate.

A solution which deposits KCl is thereby 'reactivated' with respect to carnallite: i.e. it can dissolve a further proportion of carnallite and yield a further crop of KCl etc. until its constitution reaches that of the point F_1.

These observations can be used to obtain interpretations of some otherwise not very comprehensible phenomena observed in the decomposition of carnallite in stirred solutions.

Thus it sometimes happens that when carnallite is mixed with brine saturated with respect to KCl, unsaturated to carnallite, there is no immediate yield of KCl and sometimes none within an hour. The carnallite is observed to dissolve to a slight extent, but the lack of precipitation of KCl appears to prevent the dissolution of carnallite. This is found to happen when the solution is quite near the invariant point, F_1. It also happens at points far removed from F_1 when traces of $SnCl_2$ are present in solution.

The explanation is simply that enough carnallite dissolves to bring the solution to carnallite saturation. As long as KCl does not precipitate, the decomposition cannot proceed beyond this point. The dissolution produces insufficient KCl-supersaturation to exceed the "limit of metastable supersaturation". In the absence of $SnCl_2$ the limit is not exceeded owing to the smallness of the KCl supersaturation produced by the small carnallite subsaturation. In the presence of $SnCl_2$ this limit appears to be considerably raised. The effect of tin in stabilising supersaturated KCl solutions is probably associated with its effect on the crystal habit[7].

Such a system in a state of suspended decomposition can be set going by KCl-"seeding". In a tin-inhibited system, the tin-effect is completely removed by the addition of a soluble sulphide.

This work was initiated by the Palestine Potash Company and continned under a grant from the Research Council of Israel.

REFERENCES

1. Van't Hoff and Meyerhoffer, 1887, *Sitz. Ber. Preuss. Akad, Wiss.*, 487.
2. D'Ans, 1933, *Die Loesungsgleichgewichte der Systeme der Salze Ozeanischer Salzablagerungen*, Berlin, Tafel IV.
3. Gmelins Handbuch der anorganischen Chemie, *Kalium*, 8te Auflage, Berlin, 410.
4. Przibylla, N., 1904, *Zentralblatt fuer Mineralogie, Geologie und Palaeontologie*, 239.
5. Bloch, Lecture in Discussion on Soil Science, Haifa, April 18th, 1952; Bloch, Farkas and Litman, 1951, *Bull. Res. Counc. of Israel*, **1**, No. 1, 36.
6. Reiner, Markus, Lecture in Discussion on Soil Science, Haifa April 18th, 1952.
7. Gmelins Handbuch der anorganischen Chemie, *Kalium*, 8te Auflage, Berlin, 356.

THE CHLORIDE-BROMIDE RATIO OF THE WATER SOURCES OF THE EASTERN EMEK YEZREEL AND OF THE BEISAN VALLEY*

F. YARON and M. HEITNER
Research Council of Israel

Of the four halogens present in ocean water, only chlorine and bromine are of geochemical interest, as only they and not iodine and flourine are known to occur in oceanic deposits.

When ocean water is evaporated, the chloride-bromide ratio remains constant as long as the precipitate consists of hydroxides, carbonates and of calcium sulfate. With further concentration of the brine, the precipitation of sodium chloride begins and with this, the chloride-bromide ratio goes down, since practically no bromide is precipitated with the sodium chloride[1,2]. On the other hand, potassium and magnesium chlorides and their double salt, carnallite, are isomorphous with the respective bromides[1]; therefore, the carnallite which is precipitated from highly concentrated ocean brine, may contain appreciable amounts of bromide. Actually, it has been found[2,3,4] that carnallite occurring in Stassfurt and in other deposits contains 0.2-0.4 % bromine.

The chloride-bromide ratio may serve as an indication of the way in which an oceanic deposit has been formed. A ratio of about 295 indicates an evaporation *in situ*, whereas a lower value points to evaporation of a concentrate from which part of the chloride had already been precipitated elsewhere. On the other hand, a chloride-bromide ratio greater than that found in the ocean is possible only when a "normal" solution comes in contact with solid sodium chloride.

The Hydrological Service of the Israel Government has kindly put at our disposal water from some springs and borings of the Eastern Emek and of the Beisan Valley. These have been analyzed for chloride and bromide; for the latter, the method was used which has previously been described in this Journal[5]. The locations from which the samples were obtained are indicated on the attached map (Figure 1).

The results of the analyses (Tables I and II) show that the chloride-bromide ratio is usually much lower than 295, i.e., at least part of the solutions studied is derived from deposits of a concentrate from which part of the sodium chloride had been precipitated before.

The chloride-bromide ratio in the borings and wells is greater than that found in the springs. There are a few exceptions to this: the Sakhne boring in Beth Alpha (Number 30) which has a ratio of 202, the boring of Beth Yoseph (Number 31) which has the exceptional ratio of 134, and Bir Toubis (Number 18) which has a ratio of 170. The latter is located in the vicinity of a spring (Number 1) which has a ratio of 190. There can be little doubt that the well, the water level of which is only 2 metres deep, and the spring are of common origin.

The water of the Beth Yoseph boring owes its high bromine content both to the depth of the water level (*ca* -240 below MSL) and to the proximity of Lake Kinnereth

* Received April 1952.

TABLE I
Chloride and Bromide Content of Springs
(Milligrams per litre)

Number	Place of Sampling	Date of Sampling	Chlorine	Bromine	Cl:Br
1	Bir Toubis	7.11.1950	60.7	0.32	190
2	Ein Harod	1.11.1950	105.1	0.41	255
3	Ein as Sakhne	26.12.1950	1096.8	7.45	148
4	Ein d'Asi	25.12.1950	927.3	6.05	154
5	Jemmain	25.12.1950	247.9	0.99	251
6	Ein Fawwer	15. 1.1951	544.0	3.16	172
7	Ein el Jaussaq	15. 1.1951	220.8	0.83	267
8	Ein el Maddu	15. 1.1951	113.5	0.45	251
9	Ein Mujadda	22.11.1950	53.9	0.30	180
10	Ein ad Daugheim	1.11.1950	612.9	3.31	186
11	Ein Umm Ajra	29. 1.1951	590.0	2.95	200
12	Uyum Abbu Faraj	15. 1.1951	215.2	0.85	253
13	Uyum Sheikhet Fadda	22. 2.1951	208.5	0.87	240
14	Ein Bala	14. 1.1951	880.4	5.03	172
15	Ein as Soda	14.10.1951	1122.5	6.94	162
16	Ein Mouhaska	10. 4.1951	99.5	0.38	251
17	Ein el Belad	10. 4.1951	116.3	0.43	270

TABLE II
Chloride and Bromide Content of Borings and Wells
(Milligrams per litre)

Number	Place of Sampling	Date of Sampling	Chlorine	Bromine	Cl:Br
18	Bir Toubis III	24. 1.1951	66.2	0.37	179
19	Ein Harod, Qumi 9	1.11.1950	400.8	1.54	264
20	Tel Yoseph, Qumi 12	1.11.1950	551.0	2.09	263
21	Gilboa, quarry	17. 1.1950	105.6	0.39	220
22	Beth Hashitta A	17. 1.1951	517.3	1.92	270
23	Beth Hashitta B	17. 1.1951	293.4	1.16	253
24	Beth Hashitta C	30.10.1950	254.0	1.06	240
25	Tel Yoseph A	17. 1.1951	84.1	0.32	262
26	Heftzi-Bah B	4.12.1950	235.6	1.17	202
27	Heftzi-Bah A	17. 1.1951	264.6	0.98	269
28	Beth Alpha A-16	1.11.1950	269.9	1.09	251
29	Beth Alpha	17. 1.1951	277.9	1.07	269
30	Beth Alpha, Sakhne	17. 1.1951	427.8	2.09	204
31	Beth Yoseph	8. 4.1951	364.0	2.71	134

around which many bromine-rich springs are located. The low chloride-bromide ratio of the Sakhne and the Heftzi-Bah cannot yet be explained.

The springs may be divided into two groups, one with a ratio of 240—270 and another with ratios below 200. The division follows geographically the main fault line of the Jordan valley. Only in very few cases, two springs which are very near each other have different chloride-bromide ratios.

The springs of Ein Mouhaska (Number 16) and of Ein el Belad (Number 17), although situated far to the northeast of the main fault line, have relatively high chloride-bromide ratios (250 and 270 respectively). Topographically, they are placed high above the level of other springs (the lower approximately at MSL, the highest some 50 metres above MSL). It seems these springs draw from a local (perched) water table and have no connection either with the Beisan springs or with the surface from which the Beth Yoseph well draws its water.

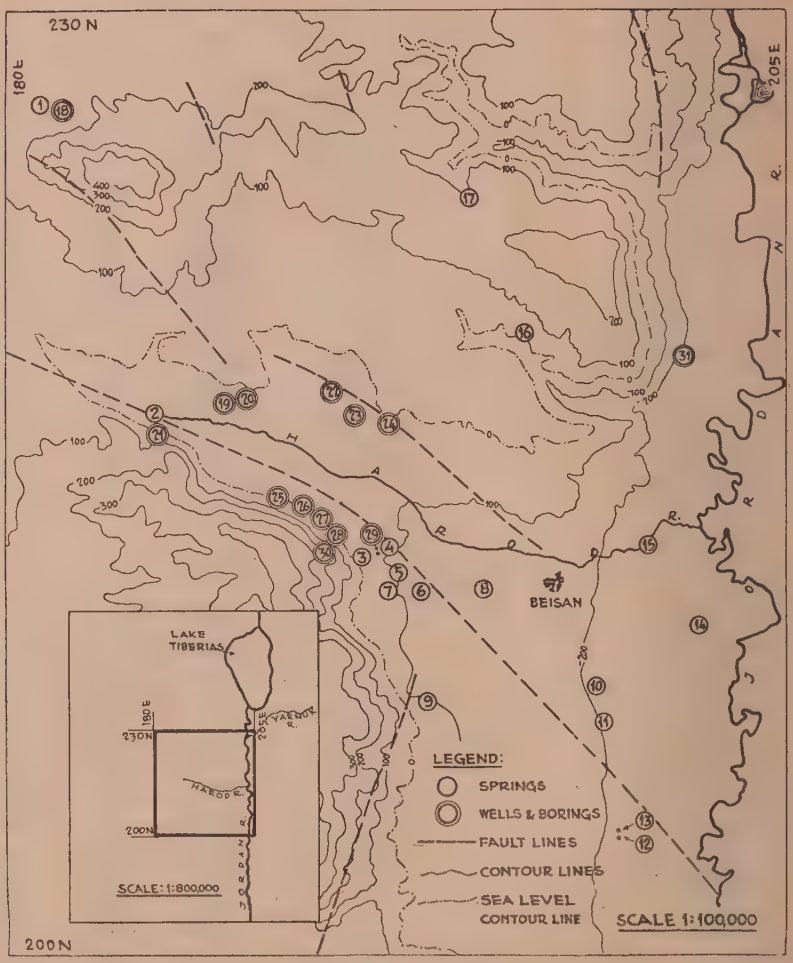


Figure 1
Key map to springs and wells and borings mentioned in the text

The role played by the Beisan springs in the supply of salts to the Dead Sea is appreciable. A mixture of samples taken from the most important springs in proportion to their contribution to the total volume discharged by these springs, analysed as follows (mg per litre): K — 9.7, Na — 292, Ca — 63, Mg_2 — 6, Cl — 599, Br — 3.65, SO_4 — 70, HCO_3 — 200. The total amount of chloride ion carried by these springs is about 60,000 tons per year, and also the quantity of bromine (400 tons) is significant.

REFERENCES

1. Boeke, H. E., 1908, *Ztschr. Kristallographie*, **45**, 346.
2. Schobert, E., 1912, *Ueber die Kristallisation von Chlornatrium und Jodnatrium aus Schmelzen und waessrigen Loesungen* (Ph. D. thesis), Berna-Leipzig.
3. Kubierschky, 1907 *Die Deutsche Kali-Industrie*, 60.
4. D'Ans, J. and Kuhn, R., 1940, *Kali, Verwandte Salze und Erdoel*, 4.
5. Bloch, M. R., Kertes, s. and Schnerb, I., 1952, *Bull. Res. Counc. of Israel*, **1**, No. 4, 82.

THE SPRINGS OF LAKE KINNERETH AND THEIR RELATIONSHIP TO THE DEAD SEA

F. YARON
Research Council of Israel

The Dead Sea was first mentioned in scientific literature during the first half of the 19th century when Angelot[1] connected its origin and that of other brackish lakes in the Mediterranean area with a sea centred where the three continents meet. Lartet[2] discussed the matter thoroughly and finally disproved this theory and also other theories on a direct oceanic origin of the Dead Sea. He recognized the role played by the Tiberias Hot Springs in the mineral supply of the Dead Sea but believed that, on the whole, the Dead Sea owed its mineral content to the leaching out of the cretaceous deposits on both sides of the Jordan Valley. Later Picard[3] put more emphasis on the Tiberias Hot Springs, which, he believed, were the source of the potash and bromine salts of the Dead Sea. In a report to the Palestine Potash Co. Picard[4] explained the origin of the bromine-containing waters of the Kinnereth springs and the high salinity of the Gilboa Springs near Beisan as possibly due to deep seated pre-Cretaceous Salt deposits. The minerals rose with the water from great depths along major rift-faults to the surface. The object of this work was to investigate in greater detail the composition of the largest springs around Lake Kinnereth, and the geochemical relation of these springs to the Dead Sea.

CHEMICAL DATA CONCERNING THE LAKE KINNERETH SPRINGS

No systematic investigation of the Lake Kinnereth springs has been made in the past. In 1950 a thorough study of the springs together with a physical and chemical survey of Lake Kinnereth were carried out[5]. Because of their elevated temperature (60°C) the Tiberias Hot Springs were best known among the many springs located in the Jordan Rift Valley. Their therapeutic value was recognized since ancient times, and their composition was the first to be investigated. The volume discharged by these springs is approximately 1 million m^3/year. Table 1 gives the results of a series of analyses of these springs. Almost all the samples have been obtained through the courtesy of the Department of Research of Water Sources. The most striking feature of the chemical composition of the springs is their high bromide content and the relative abundance of calcium. Samples taken from the same source at a few-month-intervals differ slightly both with regard to total salts content and to composition. There are also small differences between samples taken at the same time from different sources situated near each other.

The Fuliya group contains a large number of small and large springs. The total volume discharged by these springs is not yet exactly known. The various members differed much more among themselves than the Tiberias Hot Springs. Chloride

Received April 1952

contents as low as 320 mg/l and as high as 1430 mg/l have been found in samples taken during 1951. Some of the analyses of these samples are given in Table II. Here again samples taken from the same source at short intervals of time showed very small differences in so far as total chloride and bromide are concerned.

The most important springs of the Tabgha-Tannur group are Ein Tannur and Ein Tabgha. The first discharges about 20 million m^3/year and supplies approximately a quarter of all the chloride ion carried into the lake. Ein Tabgha supplies approximately 4000 tons of chloride ion, and its discharge is approximately 3 million m^3/yr. The temperature of the springs has been measured on a few occasions only. As far as may be gathered from these measurements, the springs have a temperature of about 30°C, nearly independent of the season, (the temperature of Lake Kinnereth's surface varies from approximately 15° in winter to nearly 30° in summer). Table III gives the analyses of a few samples taken from Ein Tannur and Ein Tabgha. The seasonal variations in total chloride content of each of these springs are much greater than those found in the Tiberias Hot Springs. On the other hand, the variations in cation-anion ratios are approximately of the same magnitude as those in the Tiberias Hot Springs and the Fuliya Springs. On comparing the above described three groups of springs, one can see that the Fuliya group differs considerably from the other two groups, while the latter show a greater similarity in composition. The similarity of the Tiberias Hot Springs and Tabgha-Tannur Springs is masked to a considerable extent by the difference in temperature and total salts content. The chloride-bromide ratio is similar and so is the salt sodium chloride percentage (basis, total salts). The difference in temperature is probably due to a strong dilution of the Tabgha-Tannur branch by sweet water. Penetration of sweet water to a smaller or greater extent may also account for the greater variability of the concentration in these springs.

OTHER SOURCES OF MINERAL SUPPLY OF THE DEAD SEA

The composition of Lake Kinnereth has been investigated during three surveys carried out in May-June 1950, November 1950 and March 1951[5]. It was found that with a few exceptions caused by inflow of salty water from the springs or sweet water from the Jordan, the composition of the lake is uniform. As may be seen in Table IV, the lake contains somewhat more sodium than may be accounted for by the known springs. This means that the unknown sources supply relatively more sodium than calcium and magnesium as compared to the springs described above. The ions which show appreciable variation in time or place in the lake are the bicarbonate ion and to a much smaller extent, the calcium and magnesium ions. This is caused by inflow of solid calcium and magnesium carbonates suspended in run-off water and brought from the surroundings of the lake. Bicarbonate content is also strongly influenced by biological factors such as assimilation and respiration. The Tiberias Hot Springs and the Tabgha-Tannur and Fuliya groups of springs contribute about two thirds of the minerals supplied to the lake. The remaining sources of mineral supply are either altogether unknown, inaccessible, or too small to be, measured. On the whole, the Jordan flowing out from the lake carries some 150,000 tons of chloride ion yearly, i.e. approximately half of the mineral supply of the Dead Sea. The Yarmuk River

which joins the Jordan not far downstream from the lake has a somewhat lower mineral content than the Jordan. The discharge of the two rivers are on the average which joins the Jordan not far downstream from the lake has a somewhat lower equal (approximately 500 million m^3/yr each). An analysis of a sample taken after the joining of these two rivers show an enrichment in bicarbonate, sulphate and calcium as compared with the composition of the Jordan (alone as it flows out of Lake Kinnereth). The enrichment in calcium and in sulphate is probably due to dissolved or suspended gypsum abundant in that part of the Jordan Valley. Otherwise, no significant change in the relative composition due to the inflow of the Yarmuk can be observed. The mineral content of the Yarmuk is due to some springs located not far from the junction of the Jordan and the Yarmuk. These springs have not been investigated to date, but judging from the composition of the Jordan below its junction with the Yarmuk (the composition of the Yarmuk itself could not be determined), they must be very similar to the Lake Kinnereth springs. The Beisan springs are an appreciable factor in the supply of salts to the Jordan and hence to the Dead Sea. Sufficient information, however, is not available at the moment. It is estimated that these springs bring into the Jordan some 60,000 tons of chloride ion yearly. It is also known that they contain chlorine and bromine in a ratio similar to that found in the Yarmuk and the springs around Lake Kinnereth. The percentage of sodium chloride (basis total salts) is also similar to that found in Lake Kinnereth.

The computations in this paper are based on the following assumptions regarding the Jordan River at its point of juncture with the Beisan springs: The discharge is 1000 million m^3/yr, the chloride ion content is 300 mg/l, and the chemical composition is equal to the chemical composition of Lake Kinnereth (date of survey March 1951[6]).

It should be mentioned here that practically no soluble minerals are added to the Jordan after the point at which the springs of the Beisan Valley join it[9]. Exceptions are some salts which are leached out by the Jordan or its tributaries from saline soils. These soils owe their salt content to the Jordan itself or to the Dead Sea, which once extended to the north and, in shrinking, left behind some of its salt.

On the above basis, the computed yearly supply of the Dead Sea is as follows (in thousands of tons): sodium 139, potassium 7.5, calcium 52, magnesium 15, chlorine 300, bromine 2.4.

For convenience's sake, the composition of the Dead Sea is compared in the following table not only with that of the Lake Kinnereth (in March 1951), but also with the composition of four of the most important springs which account for more than half the salts discharged into the lake. It is accepted[3] that the lakes which preceded the present Dead Sea were sweet water lakes and only after the Jordan broke through in the middle of upper Pleistocene and began to pour its waters into the lowest part of the graben, could the present Dead Sea have been formed. Assuming a constant supply from that time, the 24 billion tons of chloride ion found now in the Dead Sea would have accumulated during 80,000 years which would not fit badly into the geologically computed age of, say, 60—70,000 years (this should result in an accumulation of some 18—24 billions tons, based on the above mentioned assumption of a yearly supply of 300,000 tons of chloride ion).

If the total chloride estimated leads to no disagreement between our assumptions and the presumed age of the Dead Sea, a similar computation for any of the salts present in the Dead Sea leads to serious discrepancies. To explain these discrepancies we have to return to a discussion of the composition of the Lake Kinnereth Springs. While the magnesium chloride-calcium chloride ratio in the Dead Sea is approximately 3.5 this ratio in the Lake Kinnereth Springs does not exceed the value of 0.5 and usually is less. It is obvious that at some time the supply of magnesium chloride must have been larger. Also the bromide supply must have been considerably greater. On the other hand, the supply of sodium chloride must have been smaller than it is at present unless we assume that tremendous quantities of this salt have been deposited on its way to the Dead Sea or in the Dead Sea itself. There is no possibility of the Jordan having deposited some ten or more billion tons of sodium chloride in the Jordan Valley. Although some of the soils in the Jordan Valley are very salty due to a deposition of salt, probably by the Jordan or by the once bigger Dead Sea, still the amount of deposited salt does not total more than a million tons.

The Salt Mountain of Sdom which contains billions of tons of common salt might explain the discrepancy but for the fact that its origin is considered, on geological grounds, to be earlier than pliocenic[3]. Therefore it is doubtful whether the Mountain of Sdom is a deposit of the Dead Sea. It is even possible that it might have served as a source of supply of sodium chloride. It is actually known that sodium chloride is found in a higher ratio in the southern part of the Dead Sea, probably, due to the action of rain water on the Salt Mountain. There is still another possibility that some billions of tons of sodium chloride are lying at the bottom of the Dead Sea, covered by mud or mixed with it. The fact that the bottom layers of the Dead Sea are near or at saturation with regard to sodium chloride would speak for the possibility of this assumption. There is still nothing, however, to prove it. On the other hand the present discrepancy in the sodium chloride content between the Dead Sea and its sources may be explained in quite another way.

THE ORIGIN OF THE MINERAL CONTENT OF THE LAKE KINNERETH SPRINGS

One may bring forward two hypotheses concerning the origin of the salts contained in the mineral springs of Lake Kinnereth, volcanic and oceanic. Volcanic emanations often contain hydrogen chloride which might have reacted with magnesium and calcium carbonates to form the respective chlorides. In addition to hydrogen chloride, these emanations contain alkali chlorides and also sometimes hydrophylite, a double salt of calcium chloride and potassium chloride. The bromide content of the springs would require the presence of hydrogen bromide in the volcanic emanations which might have given origin to the mineral springs. However, hydrogen bromide is not ordinarily present in such emanations in the amounts required by the high ratio of bromide to chloride in the springs, and, therefore, the volcanic hypotheses do not seem very probable.

We shall try to trace the source of the minerals to a part of one of the seas which have frequently penetrated into the present land area. The calcium chloride content of the springs is in obvious contradiction to their supposed oceanic origin. The calcium content of the ocean is 400 mg l A ccording to Van't Hoff[7] 92.5% of

this is precipitated in the form of calcium sulphate during the first stage of evaporation. The precipitated calcium is obviously lost as a source of calcium chloride in the later stages of evaporation. Only the small part of the originally present calcium which remains can stay in a dissolved form owing to the increased solubility of calcium sulphate in the concentrated solution. Assuming that all this remaining calcium is later converted into chloride, we could explain the oceanic origin of the calcium chloride found in the springs, and later in the Dead Sea. The 6—7 billion tons of calcium chloride found presently in the Dead Sea would correspond to the calcium available in an oceanic bay of a volume of 100,000 km^3.

However, the whole hypothesis is very improbable, first because of the improbability, at the above mentioned geological epochs, of the existence of a closed oceanic lagoon of such a considerable volume in the space under consideration, and secondly, because such a body of oceanic brine would have contained sodium chloride, and magnesium and potassium salts in amounts many times exceeding those present to-day in the Dead Sea. If the Lake Kinnereth Springs contain leached out salts from an oceanic deposit, the source of calcium chloride needs some special explanation. The most plausible hypothesis is that the calcium chloride has been formed from calcium carbonate by the action of hydrogen chloride of volcanic origin or of the magnesium chloride present in the oceanic deposit. The reaction, $MgCl_2 + CaCO_3 = CaCl_2 + MgCO_3$, occurs at temperatures below 100°C and is enhanced by high temperature and pressure. It is probable that such a reaction occurred and is still occurring wherever, as in the depths near Lake Kinnereth, the oceanic solid deposits or their solution are in contact with the surrounding limestone. The ratio, calcium chloride—magnesium chloride, would, in this case, be dependent on the contact, temperature, pressure, etc, and the problem of the ratio changes in time and space would be solved.

The presence in the Lake Kinnereth Springs of constituents other than calcium chloride does not require additional explanations as far as the qualitative side of the problem is concerned.

QUANTITATIVE DEVIATIONS IN THE COMPOSITION OF LAKE KINNERETH SPRINGS AND THE DEAD SEA FROM THE COMPOSITION OF THE OCEAN

In Table V ocean water is compared with the four largest springs. Only sodium, potassium, magnesium, chloride, bromide and sulphate ions have been considered. For reference the Dead Sea composition has also been included. The bromide content of the Lake Kinnereth Springs is very high compared with that of the ocean. This is especially true of the Tiberias Hot Springs which are characterized also by a relatively low content of sodium.

The Dead Sea is still further removed from the ocean in this respect and we have therefore to postulate a gradual or abrupt change in the ratios of cations and anions in the Lake Kinnereth Springs since the time they began to discharge their contents through the Jordan into the Dead Sea. This does not, however, explain the high chloride-bromide ratio and low sodium chloride content of the springs which is compatible only with an assumption that the salts have been deposited from a partly concentrated sea which had previously deposited most of its sodium chloride in

another place and afterwards had contracted and retired into the vicinity of Lake Kinnereth and deposited its bromine-rich and sodium chloride-impoverished contents.

This deposit, changed later by inclusion of calcium chloride resulting from the reaction with the calcium carbonate, probably remained untouched, until the upper Pleistocene times, when the tectonic activities enabled the initiation of leaching out by the springs. The soluble chlorides of magnesium and calcium yielded to the leaching out action more readily until depreciation caused an absolute and relative slowing down of the rate of dissolution. Sodium chloride which at first dissolved poorly in the concentrated solution of the bivalent chlorides is now dissolving in greater proportion, either because the absolute concentration of magnesium chloride and calcium chloride is lower or because the leached out upper strata of these salts has become physically more penetrable and the water has easier access to the sodium chloride layer. Whichever of the two reasons is true, it is obvious that either of them may account for the differences in composition and variations with the seasons and years which have been mentioned above. It is evident that the waters emerging as the Fuliya springs have a better contact with the sodium chloride layer and therefore a higher sodium and lower magnesium, calcium and bromide content, while the Tiberias Hot Springs are a result of the leaching action of the layer rich in bromine, calcium and magnesium.

Further research may be able to explain the difference in temperature. It will also supply general confirmation or refutation of the above hypotheses, which should be regarded as a rough approach to a complicated problem.

SUMMARY

The unique composition of the Dead Sea and in particular the high calcium and bromine content and low sodium-magnesium ratio exclude its direct oceanic origin. A qualitative agreement between the composition of the Dead Sea and of the inflowing waters of the Jordan leads to a theory tracing the minerals of the Dead Sea to deposits precipitated in the vicinity of Lake Kinnereth by the ingressing ocean

High calcium content of both the Dead Sea and the main sources of its mineral supply, the Lake Kinnereth Springs, suggest a reaction between part of the magnesium of these deposits and adjacent limestone. Quantitative deviation of the cation ratios in the Dead Sea from those of the Jordan River and of the most important mineral springs around the lake are explained by the changes in composition of the deposits or changes in contact between the deposit and the leaching water.

The author is indebted to Mr. M. Faktory, Engineer Hydrologist in charge of the Eastern Galilee district for supplying samples at the Lake Kinnereth Springs and to Miss M. Heitner for carrying out the analyses.

REFERENCES

1. Angelot, 1943, *Bulletin de la Société de Géologie*, Ser. 1, **14**, 356.
2. Lartet, L., 1877, *Exploration Géologique de la Mer Morte, de la Palestine et de l'Idumée, Paris.*
3. Picard, L., 1943, *Structure and Evolution of Palestine*, Jerusalem.
4. Picard, L., private communication.
5. Survey of Lake Kinnereth, carried out by the Research Council of Israel, Water Department and Fisheries Research Dept., 1951.

6. YARON, F. and HEITNER, M., 1952, *This Journal*, **2**.
7. VAN'T HOFF, H. J., 1905, *Z. f. anorg. Chemie*, **47**, 277.
8. SVERDRUP, H. O., JOHN, MARTIN W. and FLEMING, RICHARD H., 1942, *The Oceans, their Physics, Chemistry and General Biology*, Prentice Hall Inc., New York, 176.
9. BLOCH, M. R., Internal Report to Palestine Potash Ltd.

TABLE I

Composition of Tiberias Hot Springs
Milligrams per litre

	Main spring	*New spring*	*Main spring*	*New spring*	*Side spring*	*Main spring*	*Main spring*
	3.1.1951	3.1.1951	2.7.1951	2.7.1951	2.7.1951	24.9.1951	12.12.1951
Na	6035	6728	6915	6915	6804	6746	6773
K	365	391	295	295	328	375	383
Ca	3372	3490	3501	3501	3491	3432	3436
Mg	822	749	584	584	604	738	736
Cl	18238	18446	18016	18174	18013	17969	17851
Br	244	249	246	248	251	245	241
SO_4	767	770	734	734	754	765	759
HCO_3	80	80	162	147	162	97	162

TABLE II

Composition of Fuliya Springs
Milligrams per litre

	Fuliya 1	*Fuliya* 5	*Fuliya* 6	*Fuliya* 1	*Fuliya* 5	*Fuliya* 8	*Fuliya* 11	*Fuliya* 5	*Fuliya* 11
	3.3.51	3.3.51	3.3.51	29.6.51	29.6.51	29.6.51	12.7.51	21.10.51	20.8.51
Na	425	426	465	448	437	477	709	406	673
K	20	14.5	10.5	6.1	8.5	16.9	36	—	—
Ca	147	149	183	106	96	130	169	149	232
Mg	17	—	—	—	—	—	—	—	—
Cl	898	900	1009	906	915	1024	1432	882	1412
Br	5.95	5.95	7.0	5.95	6.1	7.1	10.9	5.4	9.7
SO_4	119	117	119	114	114	126	173	103	170
HCO_3	93	—	—	293	293	173	66	218	151

TABLE III

Composition of Tabgha-Tannur Springs
Milligrams per litre

	Ein Tabgha	*Ein Tannur*	*Ein Tabgha*	*Ein Tannur*	*Ein Tannur*	*Ein Tannur*	*Ein Tannur*	*Ein Tabgha*
	3.3.51	3.3.51	28.6.51	28.6.51	12.7.51	20.8.51	11.10.51	11.10.51
Na	459	908	522	953	1064	965	999	587
K	—	48.0	15	40.6	47	—	—	—
Ca	250	356	193	358	338	394	374	226
Mg	16.9	—	81	59	151	—	—	—
Cl	1097	2150	1208	2132	2378	2223	2273	1325
Br	10.7	19.8	12.1	19.9	21.7	20.3	21.0	12.6
SO_4	88	164	96	157	197	179	166	95
HCO_3	73	—	145	263	191	301	207	162

TABLE IV

Composition of the Dead Sea, Lake Kinnereth and the Main Springs around the Lake
Milligrams per litre

	Dead Sea South (jetty)	*Lake Kinnereth*	*Hot Springs Main spring*	*Ein Tannur*	*Ein Tabgha*	*Ein Fuliya No. 11*
	March 1951	*March* 1951	*July* 1951	*July* 1951	*July* 1951	*July* 1951
Na	34350	131	6915	1064	522	709
K	5900	7	295	47	15	36
Ca	16300	49.0	3501	338	193	169
Mg	33400	—	584	151	81	—
Cl	177250	283.0	18016	2378	1208	1432
Br	4120	2.35	246	21.7	12.1	10.9
SO_4	1160	34.5	734	197	96	173
HCO_3	—	—	162	191	145	66

TABLE V

Composition of the Main Springs of Lake Kinnereth, of the Ocean, and of the Dead Sea
In Equivalent Percent

	Tiberias Hot Springs Main Spring	*Ein Tannur*	*Ein Tabgha*	*Ein Fuliya*	*Ocean*[8]	*Dead Sea*
Na	57.00	60.36	57.51	68.40	77.36	28.69
K	1.41	1.56	0.96	2.02	1.63	2.90
Ca	32.64	22.02	24.68	18.83	3.37	15.63
Mg	8.95	16.06	16.85	10.75*	17.64	52.78
Total	100.00	100.00	100.00	100.00	100.00	100.00
Cl	96.52	93.88	94.06	91.51	90.53	98.48
Br	0.59	0.38	0.42	0.32	0.14	1.04
SO_4	2.89	5.74	5.52	8.17	9.33	0.48
Total	100.00	100.00	100.00	100.00	100.00	100.00

* The magnesium content has been evaluated by difference.

CHEMICAL STUDIES ON TOMATOES GROWN IN ISRAEL

K. Rosenheck, W. Pilnik, J. Monselise, J. Gueron,
Shoshanna Haber-Scheim

Central Citrus Products Research Laboratory, Rehovot,
and Assis Fruit Products Co., Ramat Gan

INTRODUCTION

The present study was undertaken on the initiative of Mr. J. Ettinger of the Ministry of Agriculture of Israel, who also supplied the necessary samples.

Its purpose was the gathering of data regarding the suitability for processing of several varieties of tomatoes grown in Israel.

The following properties were determined: Size of fruit, total soluble solids, acidity, pH, colour, chloride content, vitamin C, pectic substances and pectolytic activity.

Copper content, important because of legal restrictions, is the subject of a special paper by two of us.[1]

PREPARATION OF MATERIAL

From each sample, approximately two kg of well-matured fruit, as judged by colour, were taken. (In cases in which not the whole sample consisted of fully ripe fruit, the fact is stated in the tables.) In each lot the fruit was counted, washed and its average diameter determined. The sample was then divided into four portions by cutting each fruit into four equal segments with a stainless steel knife. Each portion was thus made up by one segment from each fruit. Soluble solids, acidity, pH, colour, chloride were determined in one portion after macerating in the Waring Blendor. The second portion was also macerated immediately after cutting, together with an equal amount of a 2% oxalic acid solution and used for ascorbic acid determination. The remaining portions served for the determination of pectic substances and pectolytic enzyme activity.

ANALYTICAL METHODS

Soluble solids were determined by the refractometric method.[2] The index of refraction of the filtrate was read on an Abbe refractometer. The temperature correction was made according to Table 7 of the Bulletin No. 27L of the National Canners Association, U.S.A.[2] and the corresponding Brix value was taken from the sucrose tables.

Acidity was determined after Bigelow et al.[2] on an aliquot of macerate. As identical values were obtained by titrating an aliquot of the standard extract prepared for the

Received December 1951.

estimation of pectic substances, this latter method was used throughout this work. Acidity is expressed as weight percent of anhydrous citric acid.

pH was measured with a Beckman pH meter glass electrode directly in the macerate.

Chloride was determined according to the second procedure given by Bigelow et al.[2] and expressed as weight percent of sodium chloride.

Colour was measured and expressed according to the Munsell system.[2].

Vitamin C was determined using the visual titration method with 2.6 dichlorophenol indophenol[3], the solution used was 1 % in oxalic acid. A very small amount of a silicone antifoam agent was added, to prevent the formation of foam when bringing up to volume in the volumetric flask. Iodine titration values were also determined in all samples using a N/100 iodine solution.

Pectic substances: Recently exact analyses of pectic substances in tomatoes have been reported[4]. For the present study, comparative data were thought sufficient. They were obtained by measuring the volume of alcohol precipitate and pectic acid precipitate in a standard extract. For this purpose macerate from the Waring Blendor was transferred to the double quantity of boiling water and the boiling continued for 30 minutes. At the end of this period only a few drops of water were needed to make up the weight of the mixture to exactly double the amount of macerate used. This extract was filtered through cloth and further clarified by centrifugation. In a 15 ml centrifuge tube 5 ml of extract was then added to 10 ml of 96% alcohol and after shaking, the mixture was centrifuged for exactly 10 minutes at 3000 r.p.m. The volume of the precipitate was then read. To obtain the pectic acid precipitate 10 cc of the extract was saponified during 20 minutes with 1 ml 10% NaOH in the centrifuge tube. Then 1 ml HCl 1:1 was added, the tube well shaken and placed into a boiling water bath for 3 minutes. The pectic acid precipitate was again determined from its volume after centrifugation for 10 minutes at 3000 r.p.m.

Pectolytic enzyme activity: Determination of pectic substances as described above was made on: (i) macerate obtained by Waring blending in the presence of a commercially available detergent of the alkyl-aryl-sulfonate type (AMA) to inhibit enzyme activity[5], (ii) macerate in which pectolytic enzymes were heat desactivated after 30 seconds by the pectin extraction itself, 30 seconds being the time lapse between starting the Waring Blendor and transferring the macerate to the boiling water, (iii) macerate which, after Waring blending, was left standing for one hour at 30° C. The difference in pectic substances without enzymatic breakdown and after 30 seconds and 60 minutes of enzyme action respectively gives a comparative measure of enzyme activity.

RESULTS

Tables I and II below summarize the results obtained.

DISCUSSION OF RESULTS

Soluble solids, acidity and pH are within the range of values recorded in literature. A definite effect of irrigation is not discernible, from the present data.

Chloride content is rather high and checks with values found in our laboratory in

routine analyses of tomato paste produced during this season. According to American literature, all chloride found in tomato paste is to be expressed as added salt.

Vitamin C constitutes about 70% of the total reducing substances determined by iodine and expressed as vitamin C.

Colour: In many instances the yellow figures are quite high in the Munsell spectrum. In fact, insufficiency of the red colour is a criticism often levelled against Israeli tomato paste.

Pectic substances and pectolytic activity: Consistency, an ill-defined property of great importance to the quality of tomato paste, has been shown to be largely due to the pectic substances in the fruit[6]. Indeed, the very processing of tomatoes for the preparation of concentrates provides for quick and efficient inactivation of pectolytic enzymes[7,8]. Table II clearly shows the considerable breakdown of pectin during 30 seconds and is a good illustration for the importance of the so-called "hot break" method where tomatoes are macerated at elevated temperatures so as to inactivate the enzymes immediately. The alcohol precipitate contains, of course, also non-pectic material, probably proteins[4], and it is interesting to note that while its volume is smaller than the one of the pectic acid precipitate at the beginning, it is bigger at the end of the reaction period. This is undoubtedly due to the non-pectic fraction of the precipitate which is not degraded by the enzymes present.

SUMMARY

Data on total soluble solids, acidity, pH, colour, vitamin C, chloride, pectic substances and pectolytic enzyme activity are reported for various varieties of tomatoes grown in different localities and under different conditions in Israel.

REFERENCES

1. Monselise, J. J. and Guerson, I., To appear shortly in *Fruits et Derives*.
2. Bigelow, W. D., Smith, H. R. and Greenleaf, C. A., 1941, Bull. 27L, *National Canners Assoc.*, Washington.
3. Association of Vitamin Chemists Inc., 1947, *Methods of Vitamin Assay*, New York.
4. Kertesz, Z. I. and McColloch, R. J., 1950, *N. Y. State Agr. Exp. Sta. Bull.*, **745.**
5. McColloch, R. J. and Kertesz, Z. I., 1947, *Arch. Biochem.*, **13,** 217.
6. Kertesz, Z. I. and Loconti, J. D., 1944, *N. Y. State Agr. Exp. Sta. Bull.*, **272.**
7. McColloch, R. J. and Kertesz, Z. I., 1949, *Food Tech.*, **3, 94.**
8. McColloch, R. J., Nielsen, B. W. and Beavens, E. A., 1950, *Food Tech.*, **4,** 339.

TABLE I

No.	Variety	Provenience	Irrigated	Date of Harvest	Diameter (cm)	Fruit per kg	Brix° 20°C	Acidity w/w %	pH	Vitamin C mg %		Munsell Color					Cl as NaCl w/w%	Remarks
										Dye	Iodine	R	Y	W	G	B		
6	Bounty	Givath Hashlosha	+	25.6.51	6 - 8	7.0	5.0	0.53	4.18	13.6	21.2	51	7	—	42	—		Not ripe
13	,,	Hayarkon Solomnitzky	+	25.6.51	6 - 7	7.5	5.45	0.57	4.10	18.6	26.2	65	23	—	—	12		
22	,,	Kfar Glickson	—	27.6.51	4.5-7	10.5	5.7	0.58	4.17	22.6	32.4	85	12	3	—	—		
27	,,	Gan-Hazorea	+	27.6.51	6 - 7	9.5	4.9	0.55	4.20	21.4	29.0	78	19	3	—	—		
30	,,	,,	—	29.6.51	4.5-8	11.0	5.3	0.56	4.00	20.8	32.2	85	10	4	—	—		
52	,,	,,	+	16.8.51	4 - 8	11.5	5.0	0.67	4.08	22.0	30.4	50	40	—	10	—	0.09	Not ripe
53	,,	Givath Hashlosha	+	16.8.51	4 - 7.5	13.0	6.25	0.57	4.20	24.5	34.1	53	32	—	15	—	0.09	,,
54	,,	Gan Hazorea	+	26.8.51	4.5-6.5	11.5	5.0	0.61	4.30	17.0	26.8	67	30	3	—	—	0.12	,,
56	,,	Givath Hashlosha	+	26.8.51	5 - 7	12.0	5.5	0.42	4.22	30.5	38.3	89	9	2	—	—	0.12	
7	Early Chatham	Givath Hashlosha	+	25.6.51	4 - 5.5	15.5	5.6	0.62	4.07	19.9	30.0	84	6	10	—	—		
10	,, ,,	Beth Dagon	+	25.6.51	4-5	19.0	6.25	0.76	4.00	21.6	32.5	51	7	—	42	—		
12	,, ,,	Hayarkon Solomnitzky	+	25.6.51	3.5-5.5	20.0	5.5	0.57	3.95	21.8	32.7	82	7	—	—	11		
15	,, ,,	,, ,,	—	25.6.51	3.5-5	21.5	5.7	0.62	3.90	21.2	31.5	88	12	—	—	—		
23	,, ,,	Kfar Glickson	+	27.6.51	3.5-5.5	18.0	5.45	0.39	4.30	22.2	32.7	89	7	2	—	—		
25	,, ,,	Gan Hazorea	+	27.6.51	3.7-5.5	18.0	5.3	0.64	4.10	26.0	36.1	89	7	2	—	—		
29	,, ,,	,,	—	29.6.51	3.5-5.5	20.5	5.3	0.61	4.00	23.0	32.8	80	14	4	—	—		
41	,, ,,	,,	+	6.8.51	3 - 4.5	39.0	6.4	0.62	4.04	34.2	49.0	72	23	—	5	—	0.16	
49	,, ,,	,,	+	16.8.51	3 - 6	25.0	5.2	0.76	4.00	23.7	32.3	67	27	1	5	—	0.13	
55	,, ,,	Givath Hashlosha	+	26.8.51	2.5-5	22.5	6.9	0.59	4.18	34.0	43.6	74	26	—	—	—	0.13	
60	,, ,,	Gan Hazorea	+	26.8.51	3 - 5.5	25.0	5.2	0.57	4.18	18.0	29.0	81	15	4	—	—	0.09	
8	Marmande	Beth Dagon	+	25.6.51	6 - 7.5	10.5	5.8	0.46	4.20	20.6	30.2	84	6	10	—	—		
11	,,	Chakal Yarkon	+	25.6.51	7 - 8	6.5	7.0	0.40	4.20	17.2	27.0	77	12	—	—	11		
14	,,	Givath Hashlosha	+	25.6.51	6 - 8	8.0	5.1	0.49	4.15	19.8	28.0	64	29	—	—	7		
18	,,	Kfar Glickson	+	27.6.51	6.5-8	7.0	4.4	0.39	4.30	16.6	25.9	85	13	2	—	—		
19	,,	,, ,,	—	27.6.51	5 - 8	16.5	6.0	0.51	4.10	25.4	36.2	83	14	3	—	—		
20	,,	Givath Ada	—	27.6.51	4 - 6	14.5	6.25	0.40	4.15	28.7	38.0	80	15	5	—	—		
21	,,	Gan Schmuel	—	27.6.51	5 - 8	11.0	6.55	0.45	4.20	27.7	38.0	67	29	4	—	—		
26	,,	Gan Hazorea	+	27.6.51	7 - 8	7.5	5.7	0.54	4.10	22.7	33.1	86	12	2	—	—		
31	,,	,, ,,	—	29.6.51	5 - 6.5	12.5	5.8	4.15	24.0	24.0	33.0	82	12	5	—	—		
42	,,	,, ,,	+	6.8.51	3.5-6.5	23.0	6.1	0.65	4.10	25.6	37.0	16	49	—	36	—	0.145	
44	,,	Kfar Saba Chakal	+	6.8.51	5 - 6.5	15.0	6.3	0.60	4.14	22.8	34.0	65	20	—	15	—	0.09	
45	,,	,, Autman	+	6.8.51	4 - 6.5	17.0	7.6	0.61	4.16	30.5	43.0	72	18	—	10	—		
46	,,	,, Chakal	+	6.8.51	4 - 6.5	16.5	6.8	0.55	4.25	24.8	37.4	73	20	—	7	—	0.12	
48	,,	Givath Hashlosha	+	16.8.51	6 - 7	9.0	4.7	0.45	4.30	30.9	39.0	58	36	—	8	—	0.13	
51	,,	Beth Dagon	+	16.8.51	4 - 6	16.5	5.7	0.48	4.21	26.6	36.8	65	28	—	7	—	0.13	Not ripe
57	,,	Givath Hashlosha	+	26.8.51	5 - 8	10.5	5.5	0.47	4.25	26.0	35.8	88	10	2	—	—	0.12	
58	,,	Chakal Hayarkon	+	26.8.51	4 - 6	16.5	5.6	0.49	4.45	19.8	30.2	76	24	—	—	—	0.13	
59	,,	Beth Dagon Chakal	+	26.8.51	2.5-5	32.5	7.6	0.60	4.30	33.6	46.2	75	23	2	—	—	0.16	
61	,,	Gan-Hazorea	+	26.8.51	4.5-6	16.5	5.5	0.52	4.29	23.1	33.0	84	12	4	—	—	0.13	

TABLE I (Cont'd.)

No.	Variety	Provenience	Irri-gated	Date of Harvest	Diameter (cm)	Fruit per kg	Brix° 20°C	Acid-ity w/w %	pH	Vitamin C mg %		Munsell Color					Cl. as NaCl w/w %	Remarks
										Dye	Iodine	R	Y	W	G	B		
9	Exhibition	Beth Dagon Chakal		25.6.51	5 - 5.5	14.0	5.5	0.51	4.18	28.2	36.5	41	48	11	—	—		Not ripe
16	,,	Givath Hashlosha	+	25.6.51	4.5-5	17.0	5.8	0.50	4.30	25.9	36.7	81	19	—	—	—		
40	,,	Beth Dagon		29.7.51	3.5-4.5	20.5	6.2	0.44	4.40	26.9	38.3	84	16	—	—	—		
17	Moneymaker	Givath Hashlosha	+	25.6.51	5 - 6	14.5	5.7	0.47	4.30	28.8	40.0	80	20	—	—	—		
33	,,	Ramath Hasharon	+	1.7.51	4 - 6.5	14.5	4.6	0.35	4.20	32.4	41.0	87	7	6	—	—		
38	,,	,,	+	16.7.51	3.5-4.5	23.5	5.1	0.47	4.18	27.0	38.2	72	25	3	—	—		
39	,,	Beth Dagon	+	29.7.51	4 - 5.5	18.5	6.3	0.46	4.13	34.4	45.2	83	17	—	—	—		
43	,,	Beth Dagon Chakal	+	6.8.51	3.5-5.5	22.5	5.9	0.42	4.10	34.0	46.0	80	10	—	10	—		
24	Dwarf Gem	Gan Hazorea	+	27.6.51	3.5-6	19.5	5.1	0.62	4.05	22.0	30.1	82	15	3	—	—		
28	,,	,,	—	29.6.51	3.5-6	15.0	4.7	0.53	4.10	21.2	31.1	82	14	4	—	—		
50	,,	,,	+	16.8.51	3.5-6	17.5	4.9	0.72	4.10	17.4	25.7	75	17	—	8	—	0.12	Not ripe
62	,,	,,	+	26.8.51	3.5-5.5	16.5	4.7	0.66	4.10	15.0	24.0	84	12	4	—	—	0.12	
32	MP	Ramath Hasharon	+	1.7.51	3.5-5	18.5	5.3	0.70	3.90	26.8	35.7	86	7	7	—	—		
35	,,	,, ,,	+	16.7.51	3.5-5.5	25.0	6.0	0.60	4.00	30.5	39.7	70	28	2	—	—		
34	Vanguard	Ramath Hasharon	+	1.7.51	4 - 5.5	16.5	5.4	0.47	4.18	31.2	39.2	87	8	5	—	—		
36	,,	,, ,,	+	16.7.51	3.5-5.5	16.0	4.2	0.30	4.38	26.6	35.5	68	29	3	—	—		
37	San Marzano	Ramath Hasharon	+	16.7.51	4 - 6 2.5-3.5	28.0	4.6	0.33	4.52	24.6	33.0	72	25	3	—	—		
47	Jefferson	Kfar Saba Chakal	+	6.8.51	3 - 5.5	18.5	6.4	0.65	4.05	25.9	39.4	78	11	—	11	—	0.12	

TABLE II

PECTIC SUBSTANCES IN TOMATOES

		Immediate Desactivation by Detergent		Desactivation by heat after 30 seconds		Desactivation by heat after one hour	
		Alcohol precipitate	Pectic acid precipitate	Alcohol precipitate	Pectic acid precipitate	Alcohol precipitate	Pectic acid precipitate
52	Bounty	0.70cc	1.00cc	0.50cc	0.75cc	0.30cc	0.20cc
53	,,	0.90	1.30	0.60	0.60	0.50	0.30
56	,,	0.90	1.50	0.55	0.60	0.30	0.20
49	Early Chatham	1.00	1.00	0.80	0.90	0.30	0.25
55	,,	1.20	1.40	0.60	0.60	0.20	0.20
60	,,	1.10	1.50	0.65	0.70	0.40	0.20
48	Marmande	1.00	1.50	0.50	0.70	0.40	0.30
51	,,	1.00	1.20	0.60	1.00	0.35	0.25
57	,,	1.00	1.30	0.50	0.60	0.40	0.25
58	,,	0.90	1.30	0.25	0.45	0.13	0.12
59	,,	0.90	1.40	0.70	1 20	0.15	0.13
61	,,	1.00	1.30	0.60	0.90	0.23	0.20
50	Dwarf Gem	0.80	1.10	0.30	0.30	0.30	0.20
62	,,	0.50	1.00	0.35	0.40	0.13	0.10

STUDIES ON THE PECTASE ACTIVITY OF TOMATOES*

W. Pilnik and Gerda Rothschild

Central Citrus Products Research Laboratory, Rehovot

INTRODUCTION

During a survey of the composition of local tomatoes[1], it was found necessary to measure their pectase activity quantitatively. Three main problems attracted our attention: 1) Is the pectase linked exclusively to pulp particles—as, e.g., in orange juice—or is it also present in the natural clarified tomato juice? 2) How is pectase distributed in the various zones of the fruit perpendicular to its axis? 3) What is the pH dependence of tomato pectase?

PREPARATION OF MATERIAL

To prepare macerate, tomato pieces were Waring blended without addition of water. After standing some time, the macerate separated into two layers. The pulp particles were concentrated in the upper layer and the bottom layer consisted of almost clear liquid. This liquid which we call "Enzyme A" was filtered through filter paper to ensure exclusion of all pulp particles. The pulp was thoroughly washed by redispersing several times in distilled water until no more pectase activity could be detected in the washwater. Then the original weight of the macerate was made up by the addition of water, and the pH was adjusted to 8. After standing at 30°C for two hours, during which the pH was readjusted several times, this alkaline extract, called "Enzyme B", was filtered first through cloth and then through paper.

In order to study the distribution of pectase, 40 tomatoes were sliced perpendicularly to the axis into three parts of approximately the same thickness: the stem-end, middle section and flower-end. Average samples were obtained by reuniting the same number of slices of each of the three parts.

The following data were obtained from tomatoes of the Marmand variety.

METHOD OF PECTASE ASSAY

In principle, the method of Pollard and Kieser[2] was employed measuring methyl alcohol liberated by pectase action in a buffered pectin solution. However, the buffer capacity had to be made stronger to prevent pH shifts. Methyl alcohol was determined colorimetrically according to Bertrand and Silberstein[3], but fuchsin solution was prepared according to the A.O.A.C.[4] Table I gives the composition of the final buffered 1% pectin solution for pH 4, 5, 6 and 7. For pH 4, a few drops of hydrochloric acid were added.

* Received April 1952

As buffers, 2N primary potassium phospate and secondary sodium phosphate solutions were used respectively. Additions of 5M sodium chloride were made to ensure a constant cation molarity of 0.4975 ± 0.0035, calculated as sodium ion. Saturated sodium oxalate solution was added to prevent gelification through calcium pectate formation. A stock solution of 2% commercial citrus pectin was used.

To 50 cc of the required pectin-buffer solution, the stated amount of enzyme extract was added. The reaction mixture was kept at constant temperature, for the desired time, and then 10 cc were steam distilled to obtain the same amount of distillate. For this distillation, a micro-Kjeldahl apparatus was used.

Methyl alcohol was determined in the distillate according to the method described above. To develop colour, the reaction mixture was always kept for half an hour at 30° C. Whenever the fuchsin solution was renewed, a new calibration curve was established using distillates of dilutions of analytical grade methanol in water. A Lumetron colorimeter with the orange filter (5800 A) was used.

Pectase activity is always expressed as mg methanol per 1cc distillate as liberated from 50 cc 1% buffered pectin solution through given quantities of pectase extract at 30° C during given times of reaction. Values obtained from pectin solutions, without or with desactivated enzyme, kept within the limits of reproducibility of the determinations, i.e. 0.04 mg methanol per cc.

RESULTS

Comparison of activities of dissolved pectase and alkali extracted pectase at various pH: Table II shows the activities of "Enzyme A" and "Enzyme B" at pH 4, 5, 6 and 7. In all cases, 3 cc enzyme extract were added to 50 cc pectin solution and kept for 3 hours at 30° C. At pH 7, where optimum activity was observed, methanol was also determined after 30 minutes, 1 hour and 2 hours.

Distribution of pectase in tomatoes: Table III gives pectase activities in stem-end, middle section and flower-end of tomatoes. In all cases, 0.5 cc alkaline enzyme extract was added to 50 cc pectin solution and kept for 30 minutes at 30°C.

DISCUSSION OF RESULTS

Tomato pectase has often been described[5,6,7], and most of it has been thought to be adsorbed on the cellular tissue[8]. From Table II it can be seen that a clear filtered extract of Waring blended tomatoes shows the same activity as found in an alkaline extract from pulp. Many routine tests carried out in this laboratory during the tomato season also showed that there is always considerable activity in the clear liquid separated from a tomato macerate. The activity itself and whether it is more or less than the activity of the alkaline extracted pulp, seems to depend on the variety of the plant and seasonal variations. Table III shows that there is least pectase activity in the middle slice of the tomato. All experiments indicate a definite increase of activity with increased pH.

TABLE I

Composition of buffer pectin solution

pH	4	5	6	7
2% pectin	50.0cc	50.0cc	50.0cc	50.0cc
KH_2PO_4 2N	40.0	36.0	28.0	8.0
$Na_2HPO_4 . 2H_2O$ 2N	0.0	4.0	12.0	32.0
NaCl 5M	4.0	3.4	2.4	0.0
NaOx sat.	5.0	5.0	5.0	5.0
Water	1.0	1.6	2.6	5.0

TABLE II

Comparison of dissolved pectase (Enzyme A) and alkali extracted pectase (Enzyme B)

pH	4	5	6	7			
	3 hours	3 hours	3 hours	30 min	1 hour	2 hours	3 hours
Enzyme A mg CH_3OH/cc	0.21	0.28	0.35	0.11	0.16	0.24	0.37
Enzyme B Mg CH_3OH/cc	0.24	0.32	0.37	0.10	0.23	0.30	0.37

TABLE III

Pectase activity in different zones of the fruit (in mg CH_3OH/cc)

pH	4	5	6	7
Flower-end	0.12	0.30	0.34	0.42
Middle section	0.04	0.04	0.18	0.30
Stem-end	0.15	0.22	0.30	0.42
Whole fruit	0.18	0.25	0.30	0.44

REFERENCES

1. Rosenheck *et al.*, 1952, *This Journal*, **2**, 129.
2. Pollard and Kieser, 1951, *J. Sc. Food and Agr.*, **2**, 30.
3. Bertrand and Silberstein, 1948, *Ann. Agron.*, **18**, 137.
4. A.O.A.C. Official Methods of Analysis, 1950, *Ass. of Official Agricultural Chemists*, 7th Ed., Washington, p. 132.
5. Kertesz, 1938, *Food Res.*, **3**, 481.
6. McColloch and Kertesz, 1947, *Arch. Biochem.*, **13**, 217.
7. Hills and Mottern, 1947, *J. Biol. Chem.*, **168**, 651.
8. Willaman and Hills, 1944, *U.S. Patent*, 2,358,429.

THE ACTIVE LIME CONTENT OF SOIL AS A FACTOR IN THE DEVELOPMENT OF CHLOROSIS*

JOSEF HAGIN
Hebrew University, College of Agriculture, Rehovot

The soils of large areas of Israel are highly calcareous and deciduous fruit trees and grape vines, grown by settlements in these regions, often suffer from a physiological disease, chlorosis. Decreased chlorophyl production associated with this disease causes a low assimilation rate; leaves turn yellow, yields are low and general degeneration sets in, with final necrosis. With the resettlement of regions of highly calcareous soils, and consequent intensification of agriculture, chlorosis is a serious threat.

According to literature, highly calcareous soils are unfit for growing of fruit trees susceptible to chlorosis. Nevertheless many plantations of deciduous fruit trees are prospering in soils rich in calcium carbonate, though, near the healthy orchards we often find plots on which the trees grow poorly and show obvious signs of chlorosis. No morphological or general chemical differences are found between the soil on which healthy trees are growing and that with the chlorotic growth.

The chlorotic plots are sometimes extensive, and the economic damage is therefore considerable. Hence it seems desirable to determine the differences between the soils of healthy and chlorotic plots.

METHODS

Soil samples were taken to a depth of 120 cm. Layers of 30 cm were separated. In every plot, soil and leaf samples were taken from pairs of chlorotic and healthy trees or grapes of the same variety.

Separation of colloids from soil samples was accomplished by the decantation method. Particles smaller than 1.0μ were regarded as colloidal. Fusion analyses of soils and colloids, and all other analyses, were made according to generally accepted analytical methods. pH of the soils was determined by means of the glass electrode.

EXPERIMENTS

Soil and leaf samples were taken at the beginning of June. After one year, no significant changes were found in the health status of the trees and grapes.

Three regions, typical for soils of high calcium carbonate content, were selected: (1) In the Beth Shean valley, the vineyard of Messilot. (2) In the upper Western Galilee,

Received, September 1950.

* Abbrevation of a dissertation offered by J. Hagin to the senate of the Hebrew University, Jerusalem in fulfilment of the requirements for the degree of Doctor of Philosophy.

the orchards of Hanita. (3) On the calcareous slopes of the Ephraim hills, the vineyards and orchards of Hazorea.

Superficial examination and even the first laboratory examination of the mechanical composition and $CaCO_3$ content did not show any differences between soils of the chlorotic and healthy trees.

TABLE I

Mechanical composition and $CaCO_3$ (percentages)

Settlement and Plant	Plant Status	Depth (cm)	$CaCO_3$	Coarse Sand	Fine Sand	Silt	Clay 1—2 μ	Colloid < μ
Messilot grapes	Chlorotic	30—60	49.8	5.8	17.8	19.9	6.9	49.6
		60—90	50.9	4.8	16.6	23.8	9.7	45.1
	Healthy	30—60	52.4	6.5	20.5	25.9	8.6	38.5
		60—90	53.8	7.5	20.9	23.1	6.2	42.3
Hanita plums	Chlorotic	30—60	72.2	12.2	20.9	34.5	8.4	24.1
		60—90	71.6	8.8	20.7	35.8	8.2	26.5
	Healthy	30—60	72.1	13.2	23.0	38.1	10.1	15.6
		60—90	71.1	12.1	25.4	36.1	9.7	16.6
Hazorea pears	Chlorotic	30—60	20.6	2.6	15.7	19.5	5.6	56.5
		60—90	20.8	2.2	15.5	19.6	5.9	56.7
	Healthy	30—60	21.3	3.4	16.3	19.6	5.4	55.3
		60—90	20.4	2.6	16.1	19.3	5.7	56.3
Hazorea grapes	Chlorotic	30—60	68.9	14.1	21.0	45.1	8.3	11.5
		60—90	71.1	13.7	15.8	50.2	7.9	12.4
	Healthy	30—60	58.3	9.1	24.8	36.4	8.5	21.1
		60—90	44.0	2.5	23.8	36.2	8.4	29.2
Hazorea plums	Chlorotic	30—60	37.6	4.3	18.9	23.0	6.6	47.2
		60—90	35.6	5.1	20.5	21.3	7.3	45.7
	Healthy	30—60	34.7	3.9	17.9	21.5	7.4	49.2
		60—90	33.0	3.8	17.3	20.4	8.3	50.2

In general, there is a great resemblance between samples from chlorotic anp healthy soils within the same plot. Almost all soils are rich in $CaCO_3$ and it may be assumed that all the plants growing on them would be chlorotic. However, on part of the soils, healthy growth can be seen. In view of these results we can conclude, for the moment, that the amount of $CaCO_3$ in general has no influence upon the tendency of the plants to become chlorotic.

From Table I we can see, too, that there is no significant difference in the texture of the chlorosis-producing and normal soils.

As indicated in Table II, there are no significant differences in the pH values of the healthy and chlorotic soils. A total analysis of the soils was then made. The quantities of Si, Fe, Al, Ca, Mg, P, S, Na, K, Cl, organic matter and soluble salts were

TABLE II

pH of the soil samples

Settlement and Plant	Plant Status	Depth (cm)	pH
Messilot grapes	Chlorotic	30—60	7.9
		60—90	8.0
	Healthy	30—60	7.8
		60—90	7.9
Hanita plums	Chlorotic	30—60	7.6
		60—90	7.7
	Healthy	30—60	7.6
		60—90	7.7
Hazorea pears	Chlorotic	30—60	7.7
		60—90	7.7
	Healthy	30—60	7.7
		60—90	7.7
Hazorea grapes	Chlorotic	30—60	7.7
		60—90	7.9
	Healthy	30—60	7.7
		60—90	7.6
Hazorea plums	Chlorotic	30—60	7.7
		60—90	7.7
	Healthy	30—60	7.7
		60—90	7.7

determined. The results did not show any significant differences between chlorotic and healthy soils from the same plots.

It is apparent from these results that it is not possible to locate clear cut differences by examining the soil as a whole. Therefore the soil was divided into its mechanical fractions and each of them analysed. The first analyses showed that there are differences in the composition of the colloidal fractions. Thus greater emphasis was put on investigation of the small size fractions of the soils.

In Table III the amounts of $CaCO_3$ in the colloids are given, together with the differences within the healthy and chlorotic soils.

As shown by Table III, the chlorotic soil contains. in every case, more colloidal $CaCO_3$ than the healthy. Therefore we may assume that in these soils colloidal $CaCO_3$ has influenced the chlorotic status of the plants. Actually, we cannot say what quantity of colloidal $CaCO_3$ is necessary to produce chlorosis in plants. It may be supposed that the quantity changes from soil to soil and from plant to plant and that it depends upon many factors.

A full chemical analysis of soil colloids was made. Significant differences between chlorotic and healthy soils were found in the quantitites of Ca and Mg, as shown in Table IV.

TABLE III

Colloidal $CaCO_3$ in chlorotic and healthy soil samples and the difference between them

Settlement and Plant	"Chlorotic" Soils		Healthy soils		Differences in % of colloidal $CaCO_3$
	Depth (cm)	Colloidal $CaCO_3$ %	Depth (cm)	Colloidal $CaCO_3$ %	
Messilot grapes	30—60	14.0	30—60	8.5	5.5
	60—90	14.0	60—90	9.7	4.3
Hanita plums	30—60	10.3	30—60	4.5	5.8
	60—90	9.3	60—90	4.1	5.2
Hazorea pears	30—60	3.6	30—60	2.2	1.4
	60—90	3.3	60—90	1.0	2.3
Hazorea grapes	30—60	2.1	30—60	0.8	1.3
	60—90	3.6	60—90	0.6	3.0
Hazorea plums	30—60	7.7	30—60	3.5	4.2
	60—90	6.6	60—90	2.7	3.9

The colloids of chlorotic soils consistently contain larger quantities of Ca, than the healthy and smaller quantities of Mg. When the Mg: Ca ratio is examined, the difference between healthy and chlorotic soil colloids is even more apparent.

TABLE IV

Ca and Mg in soil colloids. 30—60 *cm Depth*

Settlement and Plant	Plant Status	MgO %	CaO %	MgO:CaO
Messilot grapes	Chlorotic	4.56	19.87	1:4.3
	Healthy	4.81	16.15	1:3.4
Hanita plums	Chlorotic	3.07	20.82	1:6.8
	Healthy	3.41	16.19	1:4.7
Hazorea pears	Chlorotic	2.00	5.97	1:3.0
	Healthy	2.49	5.02	1:2.0
Hazorea grapes	Chlorotic	2.68	14.42	1:5.4
	Healthy	3.36	4.34	1:1.3
Hazorea plums	Chlorotic	2.34	12.25	1:5.2
	Healthy	3.35	8.49	1:2.5

It appears, thus, that the Ca:Mg ratio in soil colloids has some bearing on the manifestation of chlorosis symptoms in plants. A relative surplus of Ca over Mg may influence the availability of Mg, with resulting reduction in chlorophyl production. As is known, Mg is one of the constituents of chlorophyl.

In regard to other elements, Si, Al, P, Mn, Cu, Zn, no significant differences were found, and it appears that they have no direct relation to chlorosis.

However, differences were found in the iron content of colloids of chlorotic and healthy soils. Though the quantity of total Fe did not show any relationship to chlorosis, it was found that the colloids of chlorotic soils contain relatively less ferrous iron than the colloids of their healthy counterparts. As is known, Fe is an essential catalyst in the assimilation of chlorophyl.

TABLE V

Percentage of ferrous and ferric iron and the ratio between them in soil colloids (30—60 *cm depth*)

Settlement and Plant	Plant Health Status	Fe^{+++}	Fe^{++}	$\frac{Fe^{+++}}{Fe^{++}}$
Messilot grapes	Chlorotic	4.25	0.27	15.7
	Healthy	3.45	0.42	8.2
Hanita plums	Chlorotic	3.97	0.71	5.6
	Healthy	2.69	0.94	2.8
Hazorea pears	Chlorotic	7.22	0.30	24.0
	Healthy	6.19	0.66	9.4
Hazorea grapes	Chlorotic	5.37	0.49	11.0
	Healthy	7.45	0.89	8.4
Hazorea plums	Chlorotic	6.67	0.73	9.1
	Healthy	5.49	0.85	6.4

It seems possible that the amounts of ferrous iron, i.e. of this form of iron which is available to plants, did not suffice to satisfy the regular iron requirement. There are great differences between the ratios of ferrous to ferric iron in the chlorotic soils and these ratios in their healthy counterparts. Therefore it seems that this ratio is one of the factors which influence iron availability.

In addition to the series of soil analyses desribed above, determination of exchangeable bases was made. However, no significant results were found.

During the course of further research, pH measurements of soil colloids were made. In the first determination, the soil water ratio was small, enough water being added

to give the soil a pasty consistency. The results did not yield any conclusions as to the relation of soil pH to chlorosis of plants.

It seemed surprising that the higher amount of colloidal $CaCO_3$ in chlorotic soils did not influence soil pH values. Apparently, the water used in those determinations did not provide for a sufficient degree of hydrolysis of $CaCO_3$; hence no differences were found between soils containing higher and lower amounts of colloidal $CaCO_3$. Therefore additional pH determinations were made in which the soil-water ratio was 1:5.

TABLE VI

pH values of soil suspensions having soil-water ratio 1·5; *layer* 30—60 *cm.*

Settlement and Plant	Plant Health Status	pH
Messilot grapes	Chlorotic	8.68
	Healthy	8.40
Hanita plums	Chlorotic	8.60
	Healthy	8.40
Hazorea pears	Chlorotic	8.67
	Healthy	8.40
Hazorea grapes	Chlorotic	8.60
	Healthy	8.42
Hazorea plums	Chlorotic	8.58
	Healthy	8.40

Finally, leaf analyses were made to determine the differences, if any, in the chemical composition of chlorotic and healthy leaves.

The results of leaf analyses agree generally with the results of soil examinations. The three main nutrients, N, P, and K, were sufficiently available in all soils. As a matter of fact, the chlorotic plants absorbed even more of these elements than the healthy ones. Ca content is higher, and the Mg and Fe contents are slightly lower in chlorotic leaves.

Since the differences in composition between chlorotic and healthy leaves are small they could not serve as a basis for determining deficiency or excess of any soil element. However, since the soil examination showed that there is a relation between deficiency or excess of certain soil elements and the chlorotic status of plants, the above results of leaf analyses can serve as an additional indication of the corectness of our conclusions.

TABLE VII

The chemical composition of leaves; percentage on dry matter

Settlement Plant	Plant Status	Ash	Acid res.	K	P	N	Ca	Mg	Fe	Mn
Messilot grapes	Chlorotic	12.3	1.3	1.3	0.23	3.7	2.7	0.62	0.021	0.0034
	Healthy	10.9	1.0	0.9	0.20	3.3	2.2	0.75	0.024	0.0031
Hanita plums	Chlorotic	16.3	0.2	1.8	0.23	3.4	2.9	0.61	0.021	0.0032
	Healthy	14.4	0.3	1.1	0.18	3.0	2.5	0.74	0.023	0.0035
Hazorea pears	Chlorotic	10.1	0.3	1.3	0.21	2.6	2.1	0.64	0.024	0.0067
	Healthy	8.9	0.3	0.8	0.13	2.4	1.8	0.75	0.027	0.0066

DISCUSSION AND CONCLUSIONS

The purpose of this research was to ascertain why grape vines and fruit trees suffer from chlorosis in certain soils while in similar near-by soils the growth is normal. Mechanical and chemical analyses of the soil did not show any significant differences between chlorotic and healthy soils. $CaCO_3$ content was high in all soil samples and, according to the general literature, these soils were unfit for plants susceptible to chlorosis. Though in some cases chlorosis appeared, in others, the trees and grapes were healthy. Therefore the only possible conclusion is that the total quantity of $CaCO_3$ has no influence upon the chlorotic status of plants.

It was shown that there are significant differences between healthy and chlorotic soils in regard to the colloidal $CaCO_3$ content, the former being relatively richer in colloidal $CaCO_3$ than the latter. Evidently, in cases of chlorosis, the form of $CaCO_3$ is more important than the total quantity. The following reasons may be offered for this fact: Coarse $CaCO_3$ is inactive in soil, its solubility being negligible. On the other hand, colloidal $CaCO_3$ is more active, hydrolysing to some extent, and this results in an excess of OH ions, bound to Ca, in the soil solution. These OH ions may raise the pH of the soil solution sufficiently to precipitate the iron in the form of $Fe(OH)_3$

Our work offered some evidence that the colloidal $CaCO_3$ acts in accordance with the above explanation. The first evidence is the fact that higher pH values were found in soils relatively rich in colloidal $CaCO_3$, only, however, if the pH determinations were made in a soil suspension in which the soil-water ratio was 1:5. This rise in pH may result, in some cases, in precipitation of Fe as hydroxyl.

Another evidence for the activity of the colloidal $CaCO_3$ is found in the experiment showing the solubility of Fe in dilute acids. A greater quantity of Fe was dissolved from healthy than from chlorotic soils. It can be assumed that more acid was neutralized in chlorotic soils due to the greater activity of their excess of colloidal $CaCO_3$ soils.

In the literature, two ways in which $CaCO_3$ influences Fe are given: (1) hydrolysis of $CaCO_3$ creates an excess of OH ions, which precipitates Fe. (2) $CaCO_3$ directly influences Fe, resulting in the oxidation of ferrous iron to the ferric form. Ferrous iron is regarded as being available to plants, while ferric is not. Thus oxidation renders the Fe unavailable, as is the case when it is precipitated.

Our results indicated that in the examined soils, $CaCO_3$ is active in both ways; first, in precipitating Fe as shown above, and second, as an oxidizing agent, as illustrated below.

Colloids of chlorotic soils were found to contain less ferrous iron than their healthy counterparts. If we assume that $CaCO_3$ is active in oxidizing Fe^{++} to Fe^{+++} and keeping it in this form, it is clear that colloidal $CaCO_3$ is the principal activator and relatively lower quantitites of Fe^{++} will be found with relatively higher amounts of colloidal $CaCO_3$. The relatively higher quantities of colloidal $CaCO_3$ in "chlorotic" soils thus render the iron unavailable.

Finally, it should be mentioned that, in comparison with healthy soils, the Mg to Ca ratio was smaller in chlorotic soils. This may cause disturbances in chlorophyl production as a result of a reduced intake of Mg by the chlorotic plants.

A related phenomenon should be considered in this connection. After a rainy winter, or following heavy irrigation, the symptoms of chlorosis are more pronounced. It is possible that in the presence of excess water, $CaCO_3$ hydrolyses to a greater extent. This results in higher pH and increased precipitation of Fe. The availability of Fe is thus reduced, the chlorophyl production disturbed, and plant leaves turn yellow.

SUMMARY

This investigation was carried out to clarify the reasons why chlorosis appears in certain plots and not in others, even though the soils examined resemble one another in morphology and in general chemical composition.

Soil samples were taken from three regions whose soils are rich in lime: Beth Shean valley (Messilot settlement), the western Galilee (Hanita settlement), and slopes of Ephraim hills (Hazorea settlement).

pH assays were made of these soils, as well as determinations of their mechanical and chemical composition. These analyses did not show significant differences between chlorosis-producing and normal soils. A complete analysis was made of the colloidal fraction. It was shown that a relation exists between the quantity of lime found within the colloidal fraction and the appearance of chlorosis in plants. It was found, too, that lime influences the form in which iron is present in the soil. In the presence of a relative excess of colloidal lime the quantity of ferrous iron decreases.

It was also brought out that the ratio of calcium to magnesium in the colloids is greater in chlorosis-producing soils.

pH determinations were made in which the ratio of water to soil was 5:1. As a rule it was found that the pH of chlorosis-producing soils was slightly higher than that of normal soils.

Soils were extracted by varying dilutions of HNO_3. It was found that iron from chlorosis-producing soils has a lower solubility in these acids than that of normal soils. This would indicate a high neutralizing-power of the colloidal lime on the acid

Analyses were made of leaves taken from trees on the same plots as the soil samples. These analyses bore out the results obtained on the soils.

ACKNOWLEDGEMENT

This work was carried out under the supervision of Prof. S. Ravikovitch at the Hebrew University, Jerusalem. I wish to express my gratitude to him for his helpful assistance.

REFERENCES

1. Buehrer, T. F. and Williams, J. A., 1936, *Univ. Arizona Agr. Exp. Sta. Tech. Bull.*, 64.
2. Drouineau, G., 1943, *Ann. Agr.*, **13**, 16.
3. Gilbert, B. E., Forman, T., McLean, T. F. and Hardin, L. J., 1926, *Soil Sc.*, **22**, 437.
4. Gile, P. L. and Carrero, J. W., 1920, J. *Agr. Res.*, **20**, 33.
5. Haas, A. R. C., 1942, *Plant Phys.*, **17**, 27.
6. Kelley, W. F., Dore, W. H., Woodford, A. O. and Brown, S. M., 1939, *Soil Sci.*, **48**, 201.
7. Kliman, S., 1937, *Proc.Soil Sci. Soc. Am.*, **2**, 385.
8. Reuther, W. and Crawford, C. L., 1946, *Soil Sci.*, **62**, 477.
9. Reuther, W. and Crawford, C. L., 1947, *Soil Sci.*, **63**, 227.
10. Thorne, D. W. and Wallace, A., 1944, *Soil Sci.*, **57**, 299.
11. Vidal, J. L., 1937, *Compt. Ren. Seance. Acad. Sci.*, **205**, 1092.

To the memory of Rene Neuville, pioneer in the exploration of the prehistory of this country.

THE PLEISTOCENE PEAT OF LAKE HULA

L. PICARD
Geological Institute, Government of Israel and the Hebrew University, Jerusalem.

A. PALAEOCLIMATIC CONCEPTS

A decade ago, the Pleistocene climate of our country was generally believed to be similar to the present day humid Central-European, or even boreal North-European, climate[1,2,3]. This view was rejected[4,5,6,7] together with that expressed in recent years[8,9] according to which tropical conditions reigned in Pre-Mousterian time.

Our arguments were based on an analysis of the prehistoric living world and on the interpretation of fossil soils and sediments. They led in each case to the same results. "A Pleistocene Mediterranean sub-tropical climate, although subject to heavier and more lasting precipitation than that at present"[4] (p. 234).

"The present-day climatic zones of Palestine, i.e. arid desert of the Jordan valley in the East, Mediterranean seasonal climate of the hill country in the West, were—apart from insignificant fluctuations as regards time and place—already developed in the Pleistocene."[6]

The last chapter of *Structure and Evolution of Palestine*[7] (p. 119) again expressed the view that the Mediterranean climate, there termed Levantinian for our region, had a marked tendency to "fluctuations" which were conducive to the "shifting of the Mediterranean conditions in the mountains westward or eastward, and arid conditions in the Jordangraben northward or southward".*

At the time of this last publication (1943)[7], observations were too scanty or were not sufficiently developed to permit broader discussion of the Neozoic history of the Hula basin. In the following years, however, more journeys and new borings in Galilee have matured our tectonic and stratigraphic speculations. Accordingly, we have been led to infer that from the beginning of the Pleistocene at least, the Hula

* Rene Neuville, in his last monumental work on the Palaeolithic and Mesolithic of the Judean desert, has fully accepted our climatic conception. Likewise, his co-workers on macro- and micro-faunas, Vaufrey[11] (p. 217), and Haas[12] (p. 232), have arrived at the same conclusions. Shalem, in a recent paper[13], even goes so far as to deny any difference whatsoever between the climate of today and that which obtained throughout the entire Quaternary; he regards a distinction between Pluvial and Interpluvial stages as superfluous.

We can hardly follow this extreme point of view: it seems inconceivable that so gigantic an ice-sheet as that which covered most of Central Europe, the Alps and Prealps during the Riss period, there producing meterological "highs", should not have effected antithetic "lows" on the adjacent Mediterranean region.

The question may be raised, however, as to the justification of synchronizing the arrival or end of every Glacial period with the start or termination of every Pluvial period; and correspondingly to correlate every Interglacial with every Interpluvial period.

We adhere to a previous footnote remark[7] (p. 68): "As is well known, the last Interglacial period was reigning in South Italy and Spain at a time when the North was already undergoing its fourth Glacial period".

basin has been a distinct tectonic unit separated from the rest of the Jordan Rift-valley.

On adding to this conclusion our conception of a Pleistocene Mediterranean climate, as clearly evidenced by the fossil terra rossa found in the inter-montane basins, we deduced that such recent soils and peats as those of the Hula depression might well have been already in formation during the Pleistocene itself. Thus, when discussing the reclamation projects of the Hula swamps at a government committee, we proposed in 1949 that an exploratory drill be sunk to a depth of 100 metres in search of fossil peat. After the first and successful test in the autumn of 1950, 1 km north of the Jordan mouth, further borings near and around the Hula lake not only confirmed the original discovery but also revealed unusually thick deposits of prehistoric peat.

B. FLORA OF THE PLEISTOCENE PEAT

Quite apart from their practical significance, the scientific aspects of these findings are of immediate interest. They provide a means of enriching our knowledge of the Pleistocene geography of Israel and the Levant, in the first place, by a study of the contained flora. When, therefore, Mrs. Pnina Brotzen of the Swedish Geological Survey, whilst on a joint trip to Lake Hula, offered to take some bore samples to Stockholm for pollen analysis, her kind proposal was gladly accepted. Three samples were taken by her, two of them of peat, derived from depths of 31 metres and 80 metres, and the third a limnic clay characteristic of the "sterile" peat-free layers, derived from a depth of 120 metres.

Dr. Fritz Brotzen, to whom we are so much indebted for his keen interest and help, in common with Mrs. Brotzen, determined *Cedrus*, *Cypressus*, Oak and *Gramineae* before handing over the material to Dr. Erdtmann, Director of the Pollen Research Institute, Stockholm, for further analysis. We are extremely grateful to Dr. Erdtmann for the following list, as submitted to us in Dr. Brotzen's letter of 4.12.1951: Peat at 31.8 m depth: *Typha*, *Artemisia*, *Gramineae*, *Cyperaceae*, *Chenopodiaceae*, *Myriophyllum*, cf. *Lythraceae*, cf. *Nymphaea*, cf. *Pinus;* Peat at 80 m depth: *Quercus*, ferns and needle wood (*Cedrus?*); Clay at 120 m depth: *Quercus*, *Gramineae*, *Cypressus*, *Compositae*.

According to Dr. Brotzen, the pollen is better preserved in the clay than in the peat.*

Although of a generic and provisional character, these determinations reveal only endemic floral elements growing at present in the country.** Our belief in the persistence of the Quaternary climate is thus strengthened by the floral ecology.

A further proof may be seen in the physical and chemical similarity between the fossil and surface peats: the specific properties of the latter have been described by Reifenberg and Moshicky[15] (pp. 177-180) as "due to the Mediterranean climate".

* My late colleague A. Eig determined *Euphorbia berythea* from a related clayey lake sediment of the Middle Pleistocene Lisan series of the Wadi Bireh, south of Tiberias[4] (p. 192).

** References to the flora are found in the latest publication on the Hula vegetation by Zohary and Orshansky[14].

C. REVIEW OF THE PLEISTOCENE GEOLOGY OF THE MIDDLE LOWER JORDAN VALLEY

Years (B.C.)			Central Southern Jordan Valley	Hula-Depression: Mahanaim-Aiyeleth	Hula-Depression: Lake Hula	Hula-Depression: Jisr Banat Jaqub	Flora	Fauna
100,000	Upper Pleistoeene	Pluvial C (Wuerm)	Development of Jordan drainage pattern					
		Interpluvial						
300,000	Middle Pleistocene	Pluvial B (Riss)	Lisan Series	Hindaj Alluvial Fan	?	Levallois?		
			Basalt	Basalt		Basalt		*Vivipara aff. apamea*, unicolor etc.
400,000	Transition	Interpluvial (Mindel)	Naharaim Gravel	Hatsor Gravel	Hula Series	Upper Acheulean Middle		*Melanopsis turriformis, aaronsohni* etc.
			Faulting, endemic graben folding, volcanism Basalt					*Dreissensia* sp.
	Lower Pleistocene	(Guenz) Pluvial A (Villa-Franchean)	Melanopsis Stage Samra Series Gompholites (and terra rossa)	Mahanaim and Aiyeleth Hashahar Lacustrine-Limnic Series	Hula Series	Lower Acheulean to Upper Abbevillian		*Elephas aff. trogontherii*
600,000			Formation of Jordan Rift Valley and Basin Ranges in E. Galilee					
	Upper Pleiocene		Plateau Basalt					

When considering the close relationship between the Hula depression and the other parts of the Rift valley, a review of the Central and Southern Jordan valley becomes pertinent.

At the end of the Pliocene, regional basalt effusions forming plateau basalts covered the elevated Tertiary sub-soil of East Galilee. The N-S directed Jordan graben originated with the first down-faulting at the turn of the Pliocene to the Pleistocene. Crescentic and diagonal faulting produced a series of NW directed tilted blocks. The Plateau basalts in the graben were then hidden by the succeeding sediments of the Pleistocene. The tilted blocks were converted into louderbacked mountains dominating the landscape between the plains of Beisan and Genezareth. Rivers poured gravels, meadow loams and downwashed terra rossa into the newly formed depressions where they became intermixed with true lake deposits.

On the western flank of the Dead Sea and in the Southern Jordan graben, this limnic fluviatile series is known as the Samra Series; in the Central Jordan graben

as gompholites. Both are referred to the Lower Pleistocene[7]. To this epoch we now assign the so called Melanopsis-stage as seen south of Lake Tiberias, previously regarded as Upper Pliocene. The Samra and Melanopsis Series, therefore, falling in step with the recent trend in European Diluvial Chronology[16], belong to the Villafranchean or lower part of the Lower Pleistocene (about 600,000 years old).*

The freshwater character of many of the Melanopsis-Samra beds might be due to an outlet of the Lower Pleistocene lakes into a lower basin, or into the Mediterranean itself. It is not yet possible, however, to define any hydrographical pattern for these oldest Pleistocene rivers nor to detect indications of a fossil River Jordan draining the Lower Pleistocene graben.

The fauna of the Melanopsis stage resembles the present day Lake Tiberias fauna, but genera like *Vivipara* and species such as *Melanopsis aaronsohni*, *M. obeidensis*, *Neritina unicarinata* and *N. bicarinata* have been extinct since the Middle Pleistocene.

Above the beds of the Melanopsis stage follows the Naharaim Series. This consists in the main of coarse gravel and loams and is therefore considered to correspond to the Gunz-Mindelian of Europe or the upper half of the Lower Pleistocene (500,000-400,000 B.C.); it may even comprise our following Pre-Lisan "Interpluvial". We had, in fact, already in 1932** interpreted as of Interpluvial origin those reddish loams, sandy loams and loess-like materials which are intermingled with the Naharaim gravels; and in 1943 still spoke of "halts within the great fluviatile cyle of the Lower Pleistocene".[7] Future research will have to take these eluvial horizons into consideration when subdividing our Lower Pleistocene (Pluvial A).

Widespread basaltic lavas with occasional tuffs cover the Naharaim Series, separating it from the overlying Middle Pleistocene Lisan Series. These eruptions took place in the time interval between Lower and Middle Pleistocene (about 400,000 to 300,000 B.C.) and were accordingly referred by us to an Interpluvial succeeding Pluvial A but preceding Pluvial B. It is most likely that many of the fissure basalts now found south of Tiberias at the foot of the western flank of the graben belong to this well developed volcanic phase***. It will be shown in the analysis of the Mahanaim borings that this volcanic activity may have started in "Naharaim" times.

The Naharaim "stage" is further distinguished by strong tectonic disturbances leading to faulting and endemic graben folding. We are inclined to place these movements at the beginning (folding of the Melanopsis Series) and at the end (formation of fissure eruptions) of the Naharaim stage. No particular aquatic fauna has yet been recognized from the Naharaim gravels.

The following Lisan Series regarded as Middle Pleistocene is thus in the main contemporaneous with the European Riss period (250,000-150,000 B.C.). During this period the greater part of the Jordan valley was occupied by a huge playa lake extending from south of the Dead Sea to near Tiberias, but not to the Hula region, which

* This consequently leads to an Early Pleistocene dating of the so-called Levantinian stage.

** In this publication, the following misprints explaining Table 19, Figure A and footnote p. 185 must be corrected.

In the footnote the following alterations should be made; Nos. 2 to Ia: 3 to 2; 4 to 3; 5 to 4; 6 to 5; 7 to 6.

The explanation to Table 19, Figure A, should be changed as follows: I, Ia, *Melanopsis tufa* s.str.; 2. passage bed; 3. Naharaim gravel; 4. top Naharaim Series; 5. Basalt; 6. Lisan gravel.

*** The N—S directed basalt dykes and ridges on the western graben border between Tiberias and Menahemia were never found to have penetrated the Lisan beds.

remained an isolated depression. No outlet to the Mediterranean existed from the Jordan depression, which must have been no less arid than the present area around the Dead Sea. Nevertheless, Mediterranean winter rains in the adjacent mountains were plentiful, as evidenced by the numerous gravels frequently found interbedded amongst genuine playa varves of clay, gypsum and occasional freshwater chalk (the latter occurring south of the Dead Sea). These playa varves, actually, predominate only in the upper section of the Lisan Series.

One of the main drainage arteries, the Yarmuk river, built a gigantic delta which reached to the present Tiberias region. The fauna of this delta is of still more recent aspect, containing only a few species now extinct from Lake Tiberias, such as *Ancylus daganeanus* and *Neritina chalucina*.

In the Upper Pleistocene, the Lisan lake completely dried up, and there formed in its place a high plain terraced by the successive shrinking of the lake's shores. Into this elevated plain a N-S running river—the Jordan—carved a richly branched drainage pattern in the soft ground of Middle Pleistocene desiccated sediments. It is only within the last 100,000 years that the rivers of the Hula depression regained an outlet into the Tiberias basin. The Tiberias lake then became populated with those relic forms such as *Unio* and *Corbula* which were derived from the "colder" North (some forms such as *Ancylus* remaining in the Hula) and thus became transformed into a freshwater interlake.

The good preservation of volcanic cones mounted on the older plateau basalts of the Hauran, and of basaltic protuberances on the back of the tilted block mountains in SE Galilee, suggest young Pleistocene eruptions. This youthful vulcanism, to whose influence we ascribe hot springs and travertine deposition, is apparently free of larger lava streams or sheets and plays no significant role in the building of the Rift valley landscape.

D. THE PLEISTOCENE OF THE LAKE HULA AREA

1. *Tectonic position*

Observations in Eastern Galilee have more and more confirmed the existence of a typical basin-range structure[7] (p. 28) intimately connected with the graben tectonics (p. 82). The tilted blocks with their Eocene foundation and cover of sheet basalts in the "basins" and "ranges" around the Tiberias region are in fact genuine louder-backed mountains rivalling in every geological and morphological aspect the mountains of Oregon and Nevada[17] (p. 360). Structures such as those caused by the Tabgha faults are now to be noted in the NW corner of Lake Tiberias, where the Eocene basement is again covered by basalt. The difference of 280 m in height between the Hula and Tiberias lakes might well be due to hidden Eocene blocks producing a morpho-tectonic swell, in existence since the beginning of the Quaternary.

2. *Mahanaim borings*

In the region between Rosh Pinna-Tabgha and the Jordan river, lava streams flowing down both sides of the Jordan have formed a basaltic plateau, the ridges of which

attain heights of up to 500 and 600 metres above the level of Lake Tiberias. Borings east of Rosh Pinna revealed at least 150 metres of interchanging layers of gravels, basalts and volcanic tuffs resting on Middle Eocene marine limestones.

A more detailed picture has been obtained from the borings at nearby Mahanaim, and especially from those at Aiyelеth Hashahar.

THE SECTION AS REVEALED AT MAHANAIM

Metres	*Composition*
0-20	Basalt and basalt tufa
20-120	Gravel, containing components of basalt (one thin intercalation of basaltic stratum)
120-220	Lacustrine series, alternating marls and chalks
220-240	Basal basalt, overlying the Eocene.

The upper basalt, covered by terra rossa (Hamra) forms the large plain of Mahanaim.

In a previous publication[7] (p. 58), doubt was expressed as to the Neogene age of the inland sediments of the Mahanaim borings and their outcrops north of the Mahanaim—Mishmar Hayarden road. Their low grade of consolidation and facies spoke in favour of a younger age than that of the Mio-Pliocene beds around Tiberias. The position of the basal basalt is also different from that of the Miocene basalts at Mt. Berenice near Tiberias, but as seen at Tabgha, it is identical with the plateau basalts of the louderbacked tilted blocks of Upper Pliocene age.*

The lacustrine series and the top basalt are thus contemporaneous with the Melanopsis stage or with the Naharaim gravel, and with the main Pleistocene volcanics, They correspond in time to Pluvial A and to the succeeding Interpluvial, i.e. to Lower Pleistocene (s.l.).

3. *Aiyelet Hashahar borings*

We had hitherto paid little attention to a bore log described in my 1943 notebook where an occurrence of "peat" is recorded in the Aiyelet Hashahar bore No. 3 between the depths of 32 and 39 metres. This boring, 55 metres deep, is situated in the lower course of Wadi Waqqas, 1500 m NE of the colony and 4 km SW of Lake Hula. The peat was found at a level of +90 m, or 20 m above the level of the lake (+70 m).

The peat horizon is overlain by gravel and loam (Hamra) probably belonging to the Wadi Hindaj alluvial fan, and is underlain by limnic chalk of the type found in the fossil peat series of the recent Hula borings, described later. Basalts have been found in the other higher borings situated around Aiyelet Hashahar; in bore 2, the basalt occurs at 100 m, underneath gravel; in bore 4 it occurs within limnic marly chalk; and in bore 5, above the limnic chalk and clay of "Hula" type. But at Hatsor, near the mountain border, in the Friedmann bore, outcropping basalt is underlain by gravel and meadow loam at least 100 m in thickness.

* We accept, therefore, Blake's dating[18], since confirmed by a detailed survey in an unpublished report (1945) by Y. Bentor, of the Upper Pliocene plateau basalt previously referred to as Lower Pleistocene.

One thus gains the impression that on passing towards the mountains, the limnic beds (termed "Hula Series" in the following chapter) are gradually replaced by fluviatile deposits, and that conversely, on tracing them towards the Hula, the fluviatile facies thins away.

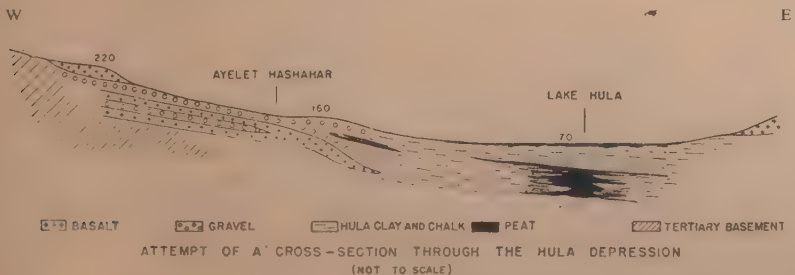
As in the case of the Mahanaim borings, the basalt of the Aiyelet Hashahar borings (at a level of 120 m) and of the outcrops at the mountain border (at a level of 220 m), define not only the age of the Hatsor gravel but also that of the limnic Hula facies. Both the fluviatile (Hatsor) and the limnic (Hula) facies of Aiyeleth Hashahar are contemporaneous with the diluvial phases of eruption which fall in the transitional period between Lower and Middle Pleistocene (or in the upper half of the Lower Pleistocene).

The probable correlation relationships are given below:

The Mahanaim top basalt corresponds to the basalt outcrops west of Hatsor; the gravel below the top basalt of Mahanaim corresponds to the thick gravel beds of Hatsor (Friedmann bore); the "intermediate" basalt within the Mahanaim gravel to the basalt of the Aiyelet Hashahar bore, which was found associated with thin super- and subjacent gravel beds and also with the uppermost layers of the limnic series. This limnic series of Aiyelet Hashahar is largely identical with the lacustrine series of Mahanaim.

The synchronizing of the top basalts with the pre-Lisan or Naharaim top basalts, and of the Mahanaim-Hatsor gravels with the Naharaim gravel, affects the correlation of the lacustrine-limnic Mahanaim—Aiyelet Hashahar Series (with fossil peat in bore 3 and in the Hula soundings). The stratigraphic position of these latter beds may either still belong to the Naharaim stage, or represent the Melanopsis stage, or comprise both stages.

The tectonic relationships between the peat-bearing Aiyelet Hashahar strata and the fossil peat strata revealed by borings in Lake Hula — discussed below — are not yet clear. The increase in slope immediately east of Aiyelet and east of the cemetry near the Yessod Hama'ala main road may be due to a slight fault, or to a bend of the strata. A comparison of the intermediate basalt of Aiyelet Hashahar at its various levels has in fact suggested such a flexuring. In this case, the top strata of the Hula borings could be contemporaneous with the limnic beds of Aiyelet Hashahar (as suggested in figure 1). If horizontality of the strata is assumed, then the Hula beds might be slightly older than the Aiyelet Hashahar beds, although the facies of the limnic series is in both cases very similar.



ATTEMPT OF A CROSS-SECTION THROUGH THE HULA DEPRESSION
(NOT TO SCALE)

Figure 1

4. *The Hula borings*

About a dozen exploratory drillings carried out by the Israel Mining Co. at the northern and western lake shore and a few kms inside the swamp, to depths varying between 50 and 120 metres, revealed fossil peat. The peat layers differ in thickness from more than 20 to less than one metre.

A combination of the various sections may be given as follows: the surface peat, a few metres thick, is underlain by a 25 m to 50 m "barren" zone of limnic chalk and clay free of peat; then follows the main fossil peat horizon. In some borings, near the Jordan mouth, this horizon is rather uniform down to 80 or more metres, whereas in others it is strongly intercalated with limnic chalks and clays. Deeper peat horizons were recently found at a depth of 120 m. No facial differences were observed within either peat or sterile beds with increase in depth, and as mentioned earlier, the basal strata of the surface peat are remarkably similar in aspect to the fossil peat. A thin bed of very fine gravels has been noted in the upper layers of a single boring on the western shore.

Freshwater molluscs of recent type, like *Planorbis*, *Bythinia*, *Valvata*, and *Melanopsidae* of the *costata* group are found in both peat and ancient lake sediments. Extinct species such as the keeled forms of *Neritina* (*Theodoxia*) *jordanica*, *Melanopsis aaronsohni* Blanckenhorn, *Vivipara aff. apamea* Blanckenhorn and *Dreissensia* sp. were found in freshwater chalk at a depth of 90 metres (—20 m M.S.L.) in a boring near the entry of the Jordan into the lake. In the south, near the outlet of the lake, the same *Vivipara* occurs already at a depth of 11 metres (+59 m M.S.L.).

The alternating beds of limnic chalk and clay with boggy peat, which are best termed Hula Series, thus, resemble, in their faunal characteristics, the Levantian or, Melanopsis stage.[19] Also from the faunal point of view, the bulk of the Hula Series has to be ascribed to the Lower Pleistocene. It follows that the "barren" lake-deposits overlying the fossil peats have originated within the Pleistocene.

5. *Jisr Banat Jaqub excavations*

Our former excavations in the Jordan bed south of Lake Hula, at Jisr Banat Jaqub, yielded the oldest known prehistoric implements; these, therefore, become of renewed interest.

The excavations were carried out in 1936 and 1937, when, for drainage reasons, the Jordan was artificially and temporarily dried up. Riots and the outbreak of the second world war prevented continuation of the work. The short reports published[17] were only of a preliminary nature, and no attempt was then made to correlate the prehistoric levels with other Pleistocene strata.

Three layers amounting in thickness to no more than 3 or 4 metres were distinguished: an upper and a lower gravel horizon separated by half a metre of a yellow-green dark clay. The upper gravel contained Levalloisian implements, the lower gravel Lower Acheulean (Upper Abbevillan), and the clay Upper Acheulean material.

In both Acheulean levels, remains of the following fossils were found:

Elephas aff. *trogontherii*, *Vivipara* aff. *apamea*, *Melanopsis* spp. A recent visit of Dr. Stekelis* produced the strongly ribbed variety of *Melanopsis buccinoidea* Olivier, figured (1933)[19] and found by us in the Melanopsis stage of the well known locality of Obeidieh, south of Tiberias.

The Acheulean clay closely resembles the barren strata of the Hula Series. This fact, together with the observation that at Jisr Banat Jaqub the Acheulean beds are definitely older than the pre-Lisan basalts covering the height of Mishmar Hayarden, adds a further justification for assigning the Jisr Banat Jaqub layers to the Lower Pleistocene, or at least to the transitional period between the Lower and Middle Pleistocene.

We again arrive, in the case of the Jisr Banat Jaqub beds, at a dating which falls in the Pluvial A or the following Interpluvial, that is the Melanopsis stage or the Naharaim stage. The topographic position of the Jisr Banat Jaqub layers 3 km south of the outlet of Hula lake and 30 m below the lake level again strengthens these stratigraphic conclusions.

E. CONCLUSIONS

The discovery of the fossil Hula peat has reopened and advanced our previous discussion on the Pleistocene of the Jordan valley.

Half of the strata drilled to a maximum depth of 120 m at and near Lake Hula, consist of layers of fossil peat. The remaining strata are predominantly ancient lake deposits of clay and chalk. The bulk of these boggy and limnic beds, termed Hula Series, is contemporaneous with the Melanopsis stage or with the Naharaim gravel; that is to say, the Hula Series are s.l. of Lower Pleistocene age, as shown in the following correlation table:

We regard as contemporaneous with the Hula Series: the other limnic, lacustrine and clastic deposits, the intercalated basalts which form the subsoils of Aiyelet Hashahar and Mahanaim, and the excavated layers of Jisr Banat Jaqub. The prehistoric implements of Jisr Banat Jaqub define the Hula Series, at least in part,as of Lower Acheulean age (pre-Rissian in European chronology). Fossil elephants and Molluscs characterizing the Melanopsis stage were found in the Hula Series. Although of a preliminary nature, a pollen-analysis of the Hula Series has confirmed our concept of a Mediterranean climate during the Pleistocene. Detailed pollen-research in the future will most certainly broaden and substantiate these ideas on the palaeoclimatology of the Levant.

REFERENCES

1. Blanckenhorn, M., 1921, "Die Steinzeit Palaestina-Syriens und Nordafrikas", *Das Land der Bibel*, Leipzig.
2. Zumoffen, G., 1926, Géologie du Liban.
3. Bergy, P. A., 1932, Le paleolithique ancien stratifie a Ras Beyrouth, *Melanges de l'Universit St. Joseph*, **26**, Beyrouth.

* Among the most recent material brought to me by M. Stekelis *Vivipara unicolor* Olivier was determined. This species lives in Africa but is known in our country only in the Melanopsis stage[19,20].

4. PICARD, L., 1932, "Zur Geologie des mittleren Jordantales". *Zeitschr. Deutschen Palaestina Vereins*, **55**, *Leipzig*.
5. PICARD, L., 1932, "Zur postmiocaenen Entwicklungsgeschichte der Kontinentalbecken Nordpalaestinas, *Neues Jahrbuch f. Mineralogie etc., Blg. Bot.*, Stuttgart.
6. PICARD, L., 1937, "Inferences on the Problem of the Pleistocene Climate of Palestine and Syria, drawn from Flora, Fauna and Stratigraphy", *Proc. Prehistoric Society*, Paper No. 5.
7. PICARD, L., 1943, Structure and Evolution of Palestine, *Bull. Geolog. Dept., Hebrew University*, **4**, Nos. 2-4, Jerusalem.
8. BATE, D. M. A., 1937, The Fossil Fauna of the Wadi el Mughara caves, in GARROD and BATE: *The Stone Age of Mount Carmel*, Part II, Oxford.
9. ZEUNER, F. E., 1950, *Dating the Past*, London.
10. NEUVILLE, R., 1951, "Le paleolithique et le Mesolithique du Desert de Judéé". *Archives de l'Institut Paleont. humaine*, Paris.
11. VAUFREY, R., 1951, *vide* NEUVILLE, R., p. 237.
12. HAAS, G., 1951, "Remarques sur la Microfauna de Mammiferes de la Grotte d'Oum Qatafa". Vide Neuville, p. 232.
13. SHALEM, N., 1951, Attributed climatic changes in the Levant, *C.R. XVI. Congres internat. Geographie, Lisbonne* 1949, pp. 489-593.
14. ZOHARY, M. and ORSHANSKY, G. ,1947, *Palestine Jour. of Botany*, Jerusalem Series, **4**, 90.
15. REIFENBERG, A. and MOSHICKY, 1941, Palestine Peat in Relation to other Peats, *Soil Science*, **51**, No. 3, 173.
16. OAKLEY, K. P., 1949, The Pliocene Pleistocene Boundary. In "International Geological Congress", *Geolog. Magazine*, **86**, No. 1, 18.
17. FENNEMAN, N. M., 1931, *Physiograpyh of Western United States*, New York and London.
18. BLAKE, G. S., 1936, *The Stratigraphy of Palestine and its Building Stones*, Jerusalem.
19. PICARD, L., 1933, "Die Mollusken der Levantinischen Stufe", *Archiv. f. Molluskenkunde*.
20. BLANCKENHORN, M. and OPPENHEIM, P., 1927, Neue Beitraege zur Kenntnis des Neogens in Syrien und Palaestina. *Geolog. Palaeontolog. Abhandlg.*, **15**, N. F. 4, Jena.
21. STEKELIS, M. and PICARD, L., 1937, 1938, "Jisr Banat Yaqub", *Quart. Dep. Antiquities Palestine*, **6**, No. 3, **4**, No. 7, Jerusalem.

AIR-PHOTOGRAPHS AND GEOLOGICAL MAPPING WITH SPECIAL REFERENCE TO THE GEOLOGICAL CONDITIONS IN THE NEGEV (SOUTHERN ISRAEL)

YAAKOW K. BENTOR
Department of Geology, Hebrew University, Jerusalem

INTRODUCTION

During the geological mapping of the Negev carried out during the last three years by Dr. Vroman and the author, extensive use was made of air-photographs. As this was the first time that this technique had been adopted in this country on a large scale during areal mapping*, it seems worth-while now to summarize the experience gained and to evaluate the advantages and limitations of the method.

It should be stressed from the outset that conditions for the use of air-photographs during this particular study were ideal. Not only were excellent photographs, on different scales, available for the whole area, but also the nature of the ground itself was eminently suitable. The Negev is a rocky desert region lacking, in most parts, any cover of soil or vegetation; no obstructing layer is here interposed between the geological sub-structure and the surface. Every detail of the geological pattern, every variation in the character of the rocks, is brought out in the air-photograph with perfect distinctness.

These conditions do not exist throughout the whole of the country; the empirical results gained in the Negev may not be applicable directly to areas such as the coastal plain or Southeastern Galilee, for example. Yet, the geographical conditions of the Negev are typical of vast regions of the Middle East, and it is suggested that the methods described herein may be of value for most of this large area.

Quite apart from the fact that the physical conditions were so favourable for the use of air-photographs, there was a technical reason which made their use preferable to normal topographical maps. The Negev is one of the lesser known corners of the earth's surface, and such maps as do exist are far from trustworthy and quite lacking in detail. The question was not one of using such intrinsic advantages as an air-photograph may possess over a map of the same area, but of using the photograph instead of a map.

It can be said without exaggeration that under existing circumstances, the geological mapping of the Negev on the scale of 1/100,000 would not have been possible at all without air-photographs.

The use of the air-photographs may conveniently be considered under three headings, corresponding to the procedure adopted in the actual work. These are: their examination before entering the field; their exploitation during the field survey itself;

* S. H. Shaws map: "Southern Palestine, geological Map on a scale of 1:250,000 with explanatory notes, Government of Palestine 1947" was partly revised in the laboratory with the aid of air-photographs.

Received January 1952

and their use in compiling results and preparing the final maps and reports after the return of the party to its base.

I. THE PREPARATORY STAGE

Air photographs are first used in order to foresee as much as possible the conditions to be encountered before setting foot in the field. A thorough examination of all morphological features is made with a large stereoscope, and an acquaintance with the nature of the area to be visited is sought.

Air-photographs are then scrutinized for purely geological information. The first aim of any geological survey in an unknown region is to secure an accurate section through as thick a series of formations as possible. Now it is a well-known fact that very large areas may be built up of only one, or even a fraction of one formation; another may show a great variety of formations as a result of local tectonic or morphological peculiarities. This difference between monoformational and polyformational areas is well brought out by air-photographs, as can be seen by a comparison of Figure 1 and 2. It is the region with the richer development that should be first examined in the field.

After this general picture of the field is obtained, the study of the air-photographs turns to details. Features suggesting faults are marked, dips are obtained wherever possible, and a tentative picture of the geological structure is built up. Special care is devoted to the discovery of isoalted, small conspicuous features, such as dark or white spots (for example see Figure 3), since these may represent special geological phenomena of small geographical extent which could easily be overlooked in the field, especially in areas of complicated morphology.

II. USE OF THE AIR-PHOTOGRAPHS DURING FIELD WORK

The use of air-photographs during the field work may be conveniently divided into those uses related to the organization of the expedition, and those bearing directly on purely geological questions.

a. Use related to the organization of the work

During work in the desert, where distances are large, a constant problem is that of finding ways along which cars may be brought as near as possible to the actual place of work. In mountainous areas the best, and often the only way for the cars lies along the beds of the frequently incised wadis. But here special difficulties arise from the frequent occurrence of dry waterfalls in the wadis, which will readily stop a car, even if only half a metre or so in height. Such waterfalls can in many cases be detected in the air-photographs (Figure 4: AA, BB).

A different case is shown in Figure 5: the photograph suggests that the obstacle could be avoided by leaving the main wadi bed eastwards along the first tributary (downstream of the fall), and then regaining the wadi bed by the second tributary above it.

Similar problems arise when it is desired that a party should leave the cars, to meet

them again later in the day at a different place. These places of rendezvous were chosen from an examination of the air-photographs. It never once happened that the party did not meet the cars at the appointed place even though no one had ever been there previously; but the geologists usually turned up several hours late.

b. Geological importance of air-photographs in the field

i. Air-photographs as geological maps

Turning to the uses of the photographs during field work, their first and in some respects their most important value lies in their being actual maps; every piece of geological information is inserted directly onto them.

Compared with an orthodox topographical map, the photograph possesses the large drawback that it has no contour lines; this deficiency is most strongly felt when estimating the thicknesses of sections. It is true that contours may be engraved onto an air-photograph in the laboratory, but an elaborate photogrammetric technique is required. This, when applied to a large area, is extremely expensive and time consuming; it might be done after completion of the field work for specially selected areas of special interest or complexity.

In every other respect an air-photograph is preferable to a topographical map on the same scale. The main advantage lies in the ease with which orientation may be achieved in the field, for air-photographs show not only all the details given in a topographical map (apart from the contours) but many others in addition. An air-photograph on the scale of 1/20,000 will show the distribution of gravels in a wadi, the larger boulders themselves, and even individual trees; the intimate forms of cliffs, waterfalls, wadi-bends and other erosional features are all reproduced with faithful precision.

The importance of air-photographs for orientation in the field is further enhanced by the following human, but none the less real, factor: that whereas a topographical map may contain a mistake, the air-photograph is never wrong. Admittedly, an air-photograph does not give an absolutely correct picture of the topography because it is subject to distortions; but these distortions are in accordance with well-known mathematical rules, and their effects may be completely accounted for. It often happens when working with a topographical map that the information given does not appear to tally with nature. Even if it turns out in the end, as it usually does, that the map was right after all, the possibility of error is constantly in the mind of the geologist and the resulting doubts may effectively injure his work. The feeling of absolute security which comes from using an air-photograph is a very real advantage in its favour.

A further advantage of the air-photograph over the topographical map is the speed with which it may be prepared. During the mapping of certain areas in the Negev the need was felt for more detailed maps than those at hand; the desired photographs were made and delivered in a matter of days. A topographical survey would have required many months, and under the existing circumstances it could probably not have been carried through at all.

Apart from its value as a map, the air-photograph gives a great deal of informa-

tion directly concerning geological questions of a tectonic or stratigraphical nature; on such vital points as these the topographical map often remains expressionless.

ii. Formational boundaries

Wherever two geological formations built up of different materials occur side by side, their boundary appears on an air photograph as a more or less distinct line. For instance, in Figure 6 the dark area represents an outcrop of Pre-Cambrian rocks surrounded by Pleistocene alluvium, which appears in the photograph in a lighter shade. It is evident that in cases such as these, the exact form of the outcrop can be mapped more accurately using the air-photograph than could be done in the field—except by instrumental methods involving much time.

What the air-photograph does not show in this case is that the Pre-Cambrian area is actually composite, containing two different rock types, granite and porphyry; this could be determined only by actual field examination of the rocks in question. Another such instance is shown in Figure 2; in the upper part of this photograph can be seen a series of alternating lighter and darker bands (EE) reflecting different horizons of the Middle Jurassic series. Even if the geological significance of the constituent strata cannot be derived from the photograph, their boundary can be mapped quite accurately.

An instructive example of the limitations of this method is shown in the same photograph (Figure 2). The large dark triangular area in the lower left part (BB) corresponds to a special rock type contrasting sharply with the lighter coloured rocks all around it. This dark area corresponds to the Jebel E-Rishe magmatic stock in Wadi Raman (coords. 135/999), which is represented on the 1/250,000 scale map of the Negev in exact correspondence with this triangular area in the photograph. However, these boundaries were mistaken, for the true limits of the stock are confined to the very dark, roughly elliptical lower part of the area. The adjoining triangularly shaped patch to the northwest is in fact a plain underlain by the Gypsum Series and covered by boulders and gravels fallen from the steep hill in the South. A closer study of the air-photographs might have indicated the presence of the underlying white gypsum within the triangular patch, especially along the small wadi courses; a stereoscopic study would have left no doubt.

This instance of Jebel E-Rishe points to one of the major limitations in the use of air-photographs in determining geological boundaries: in many cases outcrops of a given formation in place cannot be distinguished from adjoining areas covered with talus. Wherever there is the slightest doubt, therefore, geological boundaries drawn on the basis of photographs should be verified in the field.

iii. Identification of individual formations from air-photographs

The identification of specific formations is one of the most important but also most difficult uses to which an air-photograph may be put. The tone with which a body of rock is portrayed on a photograph is determined by the reflecting power peculiar to that rock. Inasmuch as rock masses of different compositions will normally possess different reflecting properties, a complex pattern of light and shade will be produced on the photograph, portraying to a greater or lesser degree the

complex pattern of rock types existing on the ground. The air-photograph, therefore, corresponds much more closely to a petrological then to a geological map.

Although the shading of formations as portrayed on the air-photograph is determined fundamentally by the nature of the rocks, or more exactly by the nature of their outer weathered crusts, the pattern of one and the same rock series may vary from place to place. This inconstancy is determined by the morphology of the area, by variation in the illumination during exposure of the photographic plate and by variation in the state of weathering of the rocks. No hard and fast rules can be given, therefore, for the differentiation of individual formations from an air-photograph.

Rocks of different age but of similar composition will as a rule appear similar in the photograph, but here surprises are possible. Two complexes whose petrology is practically indistinguishable in the field may yet show considerable differences in the photograph if they have but slightly differing weathering properties.

It follows that interpretation as to the nature of formations using an air-photograph alone is an incautious procedure. The earlier part of the field work should be devoted to systematically comparing the outcrops with their corresponding representation on the air-photographs, and to the gradual building up o fcorrelations by trial and error. Once these correlations have been established, however, the ymay be applied within a limited area with results that often prove astonishingly satisfying.

A most distinctive characteristic in the air-photograph of a formation of regional extent is its drainage pattern; Figure 7 for instance, is divided into two different parts by a sharp line running vertically from top to bottom, representing part of the cliff of Wadi Raman. The area to the left of this line is built of hard Cenomanian dolomites, the area to its right of soft Nubian sandstones of Lower Cretaceous age. There is practically no difference between the light-grey shades of these two formations as they are protrayed on the photograph, but their drainage patterns are radically distinct. The Cenomanian area contains relatively large steep-sided wadis, few in number, each showing a smooth meandering course; whereas the area underlain by Nubian sandstone exhibits a large number of small, shallow wadis, each highly denticulated and branched.

Incidentally, the wadis cut into the Cenomanian rocks show clearly hundreds of small lines perpendicular to their course: these lines represent part of an elaborate series of artificial dams dating from Nabatean times.

Notwithstanding all the diffculties attending the stratigraphical interpretation of a formation directly from its appearance on the air-photograph, such general rules will be given in the following as were gradually developed in the course of field work in the Negev.

Pre-Cambrian. An example of a Pre-Cambrian region is shown in the dark areas of Figure 8. This region, situated in the Southern Negev, is built up of magmatic and metamorphic rocks, but the different crystalline rock-types can rarely be distinguished in a photograph; plutonic, volcanic and metamorphic rocks appear as one. Only the general Pre-Cambrian age may be discerned, from the absence of bedding planes and by the characteristically sharp, angular topography.

Larger magmatic dikes may be individually visible in good photographs, and the existence of smaller ones can often be indirectly inferred if they are present in suf-

ficient numbers to affect a lineation in the topography. Such an instance where a prevalent wadi direction has been determined by a dike swarm, is shown in Figure 8; here there is a distinct NNE–SSW linear pattern.

As a whole, air-photographs are much less useful in regions of crystalline rocks than in those composed of sedimentary formations.

Nubian Sandstone. These sandstones may range in age from Cambrian to Cretaceous, but no stratigraphical subdivisions can be made from the air-photographs. Areas of Nubian sandstone are characterised by an abundance of small wadis, each distinctively crenulated, as is well shown in the right-hand side of Figure 7. Moreover, there is a marked tendency shown in the photograph towards the development of a granulated pattern and a general lack of stratification. A final characteristic of Nubian sandstone areas is the occurrence in the photograph of numerous large, but irregular, dark spots arranged either in rows or at random, (see Figure 9). On field examination, these spots are found to correspond to local developments of darker, usually ferruginous or quartzitic sandstones.

Triassic. The only large outcrop of Triassic rocks in the whole country is situated in Wadi Raman. There the section may be divided into four series: the lowermost series is composed of magmatic rocks (the Triassic basal sills); overlying this is a series of sandstones and shales (Bunter sandstone), overlain in turn by a series of limestones and dolomites (Muschelkalk); the uppermost series is composed of massive, white gypsum layers (Keuper?).

All four series are shown in the lower central part of Figure 10 (CC), the darkest colours representing the lowermost magmatic series. The sandstone-shale complex shows a drainage pattern which, in its finely sutured nature, is rather similar to that of the Nubian sandstone. Good stratification, a coarse wadi pattern, and a uniform dark grey colour distinguish the limestone-dolomite assemblage; the gypsum may be clearly differentiated as a distinctly white band, crossing the photograph from left to right (DD).

Once the significance of each colouration has been determined in the field, the boundaries between the various groups of the Triassic sequence may readily be traced using the air-photographs alone. However, in the much younger Cenomanian, occurring in the same area, there is a group of limestones and dolomites which on the air-photograph gives a pattern almost identical with that of the Triassic limestones and dolomites. Only prior stratigraphic knowledge of the existence of two such groups together with an appreciation of their relationships to some readily distinguishable marker band (in this case the white Gypsum Series), could avoid confusion.

It is not always a straightforward matter to define these boundaries, particularly that between the limestone-dolomite and the gypsum series. In the right hand part of Figure 10, the arrows H point to an area whose medium grey colour is that of the limestone-dolomite group; however, it does not belong to this group, as can be seen from the occurrence of many small patches of white which field evidence shows to be gypsum. Here in fact the gypsum group crops out more or less covered by a screen derived from the underlying, but topographically higher, calcareous series. The exact boundary is therefore masked, and in this case can be ascertained only by work on the ground.

Jurassic. Outcrops of Jurassic rocks are rather rare in the country. Wadi Raman may again be cited as an example. The section here consists of an upper and a lower series of marine limestones and dolomites, separated by a middle series of mainly continental Nubian sandstones.

Figure 2 shows the characteristics of the lower marine series; in the upper part of this photograph a series of alternating darker and lighter strips (EE) are visible corresponding to the component stages of this series.

The overlying Jurassic rocks, composed of Nubian andstones, show in air-photographs the characteristics that have already been described for this type of rock.

The right hand part of Figure 7 shows the upper marine series of the Jurassic; it appears as a dark band crossing the picture from top to bottom and is distinctly stratified (CC). The mapping of this marine series intercalated between two series of Nubian sandstones presents no difficulty and may be performed directly on the photograph.

Cenomanian-Turonian. Areas underlain by Cenomanian or Turonian rocks may be identified by their medium grey colours and rather bold erosional pattern. Wadis are few, but tend to be large and frequently canyon-like (see Figures 4 and 5).

These characteristics are not in themselves sufficiently distinctive to allow a confident interpretation, and so during the work on these rocks, an additional technique was found necessary. The underlying formation, Nubian sandstone, is easily recognisable as such in the air-photograph; therefore the examination of an area suspected to be of Cenomanian-Turonian age was begun, wherever possible, at the upper boundary of the sandstone. If the overlying formations show the above-mentioned characteristics, then they may be safely identified as Cenomanian or Turonian.

The upper boundary with the Senonian chalk and flint (see below) is even more distinctive than the lower, and precisely the same use may be made of it; but as the Senonian is much more widespread in the Negev than the Nubian sandstone, this higher boundary is the more important one.

The separation of Cenomanian from Turonian is not easy. As is well known to all field geologists who have worked on these rocks, it is notoriously difficult to fix the boundary in the absence of fossils, for the rocks of the upper Cenomanian and lower Turonian are in most cases lithologically similar. Yet, the singular position is encountered that when use is made of the air-photographs this identification is sometimes performed more easily than when working in the field. A good instance is shown in Figure 11. Whereas most of the area is portrayed as one of rather strong relief, there are two patches marked by arrows A and B, conspicuous by their uniform but dark colours. These represent remnants of Turonian beds which, notwithstanding their higher topographical position, have not been dissected by erosion and thus contrast sharply with the surrounding strongly modelled Cenomanian. Similar occurrences were frequently encountered in the Negev.

Senonian (excluding Maestrichtian). It has already been mentioned that the Senonian beds present a highly distinctive appearance when portrayed in air-photographs. The lower series (Santonian) consists of white chalk; it is overlain by an upper series (Campanian) composed mainly of flint bands.

The flints of the upper series usually develop an almost black varnish under the

prevailing desert conditions, and so contrast strikingly with the associated white chalks. The black and white pattern of the combined Senonian rocks is absolutely distinctive and immediately recognisable (Figure 12).

There are many parts of the Negev where the Santonian chalk series was not deposited; therefore, wherever a photograph shows the dark Campanian band lying directly on the pale grey Turonian without the interposition of a bright white strip, there is good reason to suspect an unconformity.

Difficulties arise with the Campanian flint itself owing to its being developed in two facies. The Charaz facies contains an abundance of flint layers; but in the so-called Isheshiye facies, the flints may be reduced to a mere twenty or thirty per cent of the total thickness. In the Isheshiye facies the flints are dwarfed by a development of chalk, often to such a degree that the series is indistinguishable in the air photograph from the underlying Santonian chalk series; such flints as there are do not take on a desert varnish and do not appear black in the photograph. Many areas that were mapped as Santonian on the basis of the air-photographs were afterwards proved by field-work to be really Campanian; this was true especially of the Wadi Fuqra region.

Yet another difficulty attends the identification of Campanian flints from air-photographs. This series has a strong tendency to yield extensive Hammada plains which are indistinguishable in the air-photograph from true Campanian flint beds in situ.

Maestrichtian-Danian. These formations are developed in the Negev as very light coloured, soft chalks and marls. Their appearance in air-photographs is therefore rather similar to that of the Santonian chalks, but they are usually not quite as white. These white series may usually be distinguished stereoscopically, for one is underlain, the other overlain, by the dark Campanian; any confusion may thus be avoided.

When developed over an extensive region, these chalks and marls give rise to well developed badlands, as shown in Figure 3. Wherever such a region of badlands occurs in contact with the dark Campanian outcrops it may safely be interpreted as of Maestrichtian or Danian age.

Eocene. The Lower Eocene is developed in the Negev as a series of chalks and marls with subsidiary flints. In the air-photographs they appear darker in shade than the Santonian-Campanian chalks; they are not dissimilar from the Maestrichtian-Danian beds just described. But as the Lower Eocene chalks are usually silicified and hardened they practically never yield badlands; they give instead a coarser, dendritic, wadi pattern, such as that well brought out in Figure 1.

The Middle Eocene of the Negev is usually formed of well-bedded hard limestones. These are very similar in appearance to the Turonian limestones both in the field and in the air-photographs, and no clear rules can be given for a ready distinction between them.

General Remarks on the Identification of Individual Formations from Air-Photographs. The suggestions contained in the foregoing paragraphs allow a reasonable inference as to the probable nature of the particular formations portrayed in the air-photographs. It cannot be over-emphasized, however, that these deductions can never be decisive.

Once the assumptions have been checked at a given spot in the field and an accurate section obtained, the inter-formational boundaries may be mapped according to air-photographs for a reasonable distance from that place, provided that the outcrops are continuous. Even under these conditions the section must be re-checked every few kilometres and in no case should extrapolation be carried out over a distance of more than ten kilometres.

This precise identification of formations from air-photographs is most difficult, but at the same time one of the most rewarding techniques with which an experienced worker may be engaged.

iv. The Identification of Isolated Outcrops

Many photographs show isolated outcrops in the form of spots, darker or lighter in colour than the surrounding formation. As a rule no stratigraphical significance can be attributed to these patches by a study of the air-photographs alone; probably more misinterpretations have been made by breaking this rule than through any other single cause.

As an instance of the unreliability of such spots, Figure 3 may be cited. Here, in the middle of an area whose badland character clearly indicates its Danian age, there occur two isolated dark spots of irregular outline (AA). When these were first found during the preparatory stages of examination, three suggestions were entertained as to their stratigraphical significance, viz: a) isolated inliers of Campanian flint laid bare by erosion, b) remnants of Lower Eocene flints overlying the surrounding Danian, or c) volcanic necks.

Examination with the stereoscope refuted the first of the three theories, for it was clearly seen that the spots are resting on hill tops and could not possibly be patches of low-lying Campanian flints. The area was subsequently studied in the field, and the patches were found to be neither Eocene flints nor volcanic in nature. In fact the material turned out to be Neogene Husb conglomerates made up mainly of flint pebbles and therefore appearing dark. This discovery was entirely unexpected and unpredictable.

Insofar as this possibility could not have been foreseen, the photograph was unreliable; but on the other hand, without knowing the occurrence of some special formation at that particular place it might easily have been overlooked altogether. As it was, once the surprising existence of Husb conglomerates in this district was appreciated other outcrops of the same formation, such as sandstone veins not visible in the photograph, were subsequently found in the vicnity.

Another good example of the difficulty in interpreting isolated spots is illustrated by the photographs of the Raman area. Interpretation of this area through the use of air-photographs alone has been responsible for many of the mistakes which appear in the 1/250,000 sheet of the Negev. The photograph of this area show a wealth of dark spots, indistinguishable one from another. Field work has shown that any one of these spots may correspond to one of the following: flint of Eocene or Campanian age. Turonian or Cenomanian quartzolith, basalt, intrusive igneous rock, ferruginous or quartzitic sandstone within the Nubian Sandstone series.

Figures 9 and 13 show different parts of the main cliff of Wadi Raman. At approx-

imately the same distance from the cliff, inside the cirque, both photographs show a similar set of dark spots. The row of spots in Figure 13 (AA) represents the main basalt sheet of uppermost Jurassic age, partly masked by recent sand accumulations and hence discontinuous in outcrop. The spots in Figure 9, being so similar in shade and position, were also designated as basalts on the Southern Palestine map, and regarded as a continuation of the same volcanic sheet. In fact, the basalt sheet does not extend into the area of Figure 9, and notwithstanding their similarity to the volcanic spots, the bodies of Figure 9 are actually outcrops of ferruginous sandstones of Middle Jurassic age.

A further case of mistaken interpretation from the Raman area is illustrated in Figure 14. This photograph shows in its southern portion the northern end of the El Hamle lobe of Wadi Raman. Both east (AA) and north (BB) of this lobe, there occur some isolated black spots within an area of Cenomanian rocks. Spot A is the more interesting; the stereoscope reveals that it is over- and under-lain by a series of white rocks and it was accordingly interpreted on the Southern Palestine map as a remnant of Senonian and Eocene rocks overlying Cenomanian-Turonian limestones (co-ordinates 148/010). But as this place lies on one of the anticlinal axes of Wadi Raman, near the area of its culmination, it was considered unlikely on purely theoretical grounds that the Senonian and Lower Eocene strata should occur there. It was accordingly decided to visit this rather inaccessible place, and the area in question was discovered to consist of a small plateau covered with numerous quartzolith fragments of Cenomanian age fallen down from the surrounding slopes. No traces of Senonian or Eocene strata are to be found in the whole of this area.

Such examples could be multiplied. They all point to the same conclusion: under no circumstances may the interpretation of isolated spots be attempted on the basis of the air-photographs alone.

v. Tectonics

It is a fact known to every field geologist that many tectonic features are better seen in the field from a distance than from close up. It is thus quite understandable that air-photographs are admirably suited to the interpretation of tectonic features, especially to those of regional extent. These larger structures, be they folding or faulting phenomena, are often far more easily discerned from the photograph than they could ever be on the ground; some of those in the Negev were actually discovered from air-craft.

Folding Phenomena. Wherever the morphology of an area is determined by the dip of its component formations, as is normal in the Negev, both the dip and the strike of the strata will be seen in the photograph, and the direction of the dip can easily be determined by use of the stereoscope. As an example, Figure 10 may be taken; in the upper part of this photograph the white and dark bands of the Lower Marine Jurassic are clearly seen dipping to the NW. If the North of the air-photograph is known, the direction of the dip can be measured with precision.

The same figure shows another and more complicated case in its middle lower part; a dark-grey area of almost elliptical shape is here visible, its centre being indicated by the arrows C. The component strata, when followed across the photograph from left to right, show a gradual swing of dip from NW, through N to an

easterly direction. The different rock formations may be differentiated by their various shades, and all can be seen conforming to this swing in the structure. The only possible interpretation is that of a tectonic dome, and, as a matter of fact, this is the westernmost of the three domes in the area of the Raman anticlinorium. In cases such as these, the whole structure may be read directly from the air-photograph.

In the foregoing case the individual beds and their inclination can be discerned in the photograph. But considerable information may be gleaned even from photographs the scale of which does not show individual beds anywhere: here tectonic considerations have to be based on the distribution of the formations, a technique similar to that used in the reading of geological maps. Figure 15 shows an elliptical area of light grey rocks, safely interpreted as Cenomanian-Turonian, surrounded by the black and white pattern so typical of the Senonian; there are a few isolated spots of dark Campanian rocks on the older grey formation, and the whole picture can mean nothing but a dome. It represents in fact one of the typical upwarps of the Eastern Negev, with well-developed Santonian chalk on the flanks, but with Campanian flint lying unconformably on Turonian in the core of the structure.

This kind of interpretation is limited when tectonic features are no longer expressed in the landscape, or where an extremely rugged relief obliterates the principal tectonic lines.

Faults. Wherever two rock complexes of different character are brought into contact through faulting, the fault ines are very conspicuous in air-photographs. As an instance, Figure 8 may be taken: the area of light grey rocks in the left part is seen to be sharply separated from a dark area to the right by a smooth, curved line. No clearer picture of a fault could be imagined. The clearness of the fault picture in this case is due to the contrast in nature between the two adjacent rock complexes: the light grey formation on the left represents Cenomanian limestones and dolomites, whereas the dark area to the right is made up of Pre-Cambrian crystalline rocks. The second dark area in the lower left corner of the picture shows again Pre-Cambrian rocks and the Cenomanian formation therefore occurs as a down-faulted block. A similar, but much smaller, rift structure can be seen on the right side of the same photograph (AA).

The air-photograph shows much more than the mere existence of a fault, for it gives in addition the exact form and position of the trace of the fault plane on the surface. By examining the behaviour of the fault line along the wadis that cut it, its exact position may usually be mapped much more accurately than could be done in the field, for there the actual area of faulting is frequently hidden by gravels and scree. In many maps the points at which a fault has actually been observed in the field are frequently joined by a straight line. The true course of a fault, however, is generally much more complex. Thus, the main fault, evident in Figure 8, is marked on the Southern Palestine map as being straight, but in fact it is arcuate and runs in a semicircle, part of which can be seen in the photograph, Figure 8.

A problem frequently puzzling the field geologist is whether or not two or more fault outcrops seen at different places belong to one and the same fault line, or whether they are members of two or more unrelated faults. Such questions can usually be solved promptly by a glance at the air-photographs of the regions in doubt.

Fault lines need not be, and are not, always so clearly marked as in the example, just quoted. Should the rock types on either side of the fault-line be similar in nature, then recourse has to be taken to other methods. In many instances the two blocks separated by a fault have each a different dip. This sudden change of dip along a more or less smooth line visible in the air-photograph is highly suggestive of a fault line; a good example of this is shown in Figure 2, along the arrows AA. Here the straight line crossing the picture separates two blocks of different dip. The southern block plunges steeply towards the S-SE, whereas the strata of the northern block are almost horizontal. This is part of the large Raman fault, another part of which is shown in Figure 16. Here again from right to left a straight line is visible (AA); in this case its form rather than the contrasted nature of the rocks on either side of it suggests that it is a fault. For this line is an escarpment which cuts obliquely across the various formations and even breaches the bounding cliff of the Raman cirque to penetrate the region beyond.

In general, wherever straight lines cut across geological structures, there are sound grounds for suspecting them to be faults. As another instance the line J in Figure 10 may be cited, representing the so-called Triassic Base Fault of Wadi Raman. During the field work in that area, it often happened that no suspicions of the existence of faults were entertained until the air-photograph was examined; only after their probable location had been deduced from the photograph were they recognised in the field.

Probably the best instance of a fault line revealing itself by its straightness is that shown in Figure 11. Here an almost straight wadi can be seen crossing the whole photograph contrasting curiously with the sinuous courses of the other wadis. This wadi was immediately suspected to follow some path of tectonic significance, and actual field investigations strikingly confirmed this view. This wadi follows a sharp V-fold for a distance of some six kilometres, and along it the strata dip inward in opposite directions without being actually displaced. These details could obviously not have been ascertained from the photograph.

III. THE USE OF AIR-PHOTOGRAPHS AFTER COMPLETION OF THE FIELD WORK

The most important step in the use of air-photographs in geological work is the preparation of the final map. If topographical maps of the area are available, the transfer of geological boundaries from the photograph to the map will present no difficulties. If no maps are available, as is usually the case in the Negev, they have to be made through photogrammetric measurements of the air-photographs, paying particular attention to the elimination of distortions. In this case, it is very helpful to have the geological boundaries marked on the original photograph itself; for then every rectification of the photograph applied to the topographical features can be simultaneously applied to the geological boundaries. A corrected geological map is thus automatically obtained.

In summing up the field results in the laboratory, it invariably happens that many points arise which have not been satisfactorily cleared up. Typical questions of this kind are as follows: is a certain geological boundary situated at the foot

of a slope or along its crest; does a certain fault cross a wadi, or did it die out before reaching it; is a given outcrop an outlier or is it actually connected with the main formation? Part of these questions can be settled by a stereoscopic study of the air-photographs, but it was usually found desirable to fly in a slowly moving aircraft over the area under debate, air-photograph in hand. After this, only rarely was it found necessary to re-visit an area in the field.

CONCLUSIONS

There can be no doubt that the development of air-photography has given the geologist a new and powerful instrument. In most respects, air-photographs are superior to normal topographical maps and are in many cases almost geological maps as well, but legendless.

Like any other single technique, the use of air-photographs has its limitations. The interpretations required are difficult, and a certain element of doubt can never be eliminated. In no case can the study of air-photographs replace actual field work, and a large measure of experience is necessary before results of reasonable accuracy can be obtained.

To many questions of urgent geological interest, the air-photograph can only offer scanty information, whereas to some it must remain completely silent. The thicknesses of section, lithographic characters of the rocks, facies variations and mineralogical and palaeontological details can never be represented by even the finest of photographs.

But in dealing with the stratigraphy and tectonics of an area, and especially during geological mapping, the air-photograph must be sonsidered a potent weapon in the hands of the field geologist, although at times a rather dangerous one.

Figure 1

Dendritic wadi pattern, typical of Lower Eocene.
Beersheba region

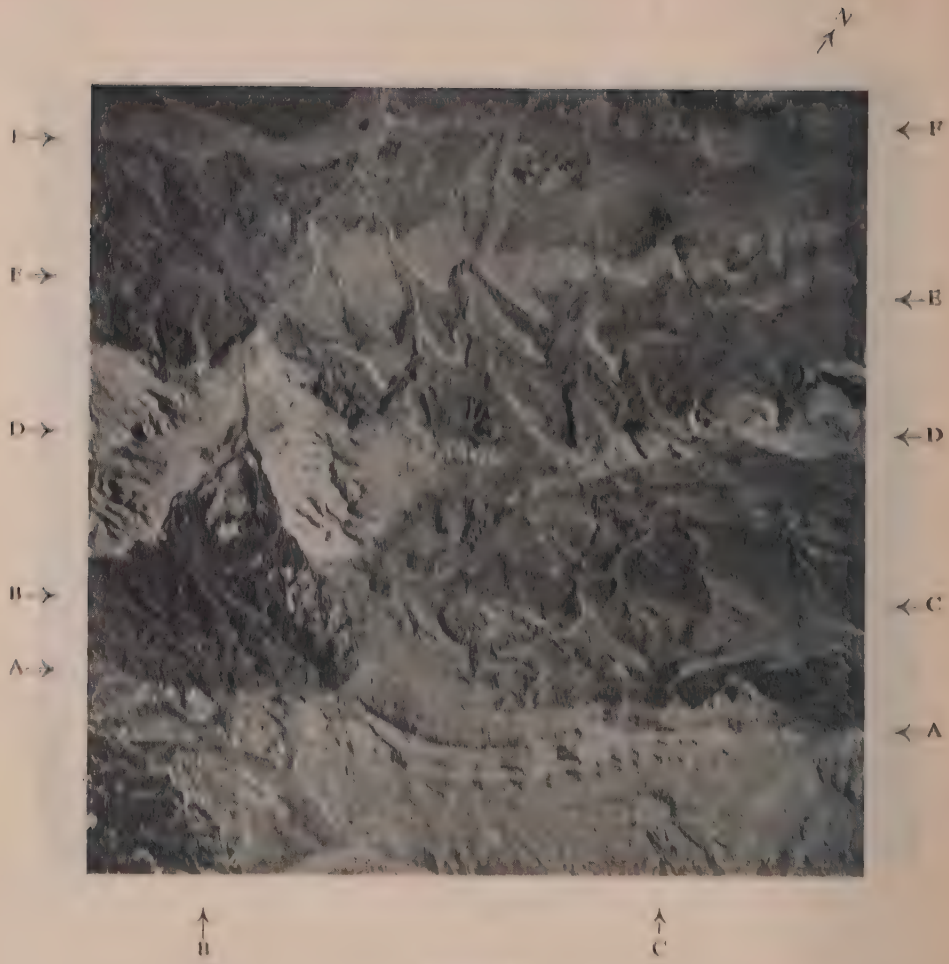


Figure 2

Core of the Raman anticline

(AA) — Fault line. South of it: cliff built by steeply inclined Cenomanian Turonian strata; to the north: almost horizontal Triassic strata.

(BB) — Black area: magmatic stock of El-Rishe.

(CC) — Dark grey area: anticlinal dome, built mainly of calcareous strata of Middle Triassic age; the dark area at its southern end: thrachytic base-sills, cut off by fault.

(DD) — White band: Upper Triassic gypsum series.

(EE) — Alternative light and dark grey bands: Middle Jurassic limestone, different shades indicating different stages.

(FF) — Medium-grey area: Middle Jurassic Nubian Sandstone.

Nahal Ramon

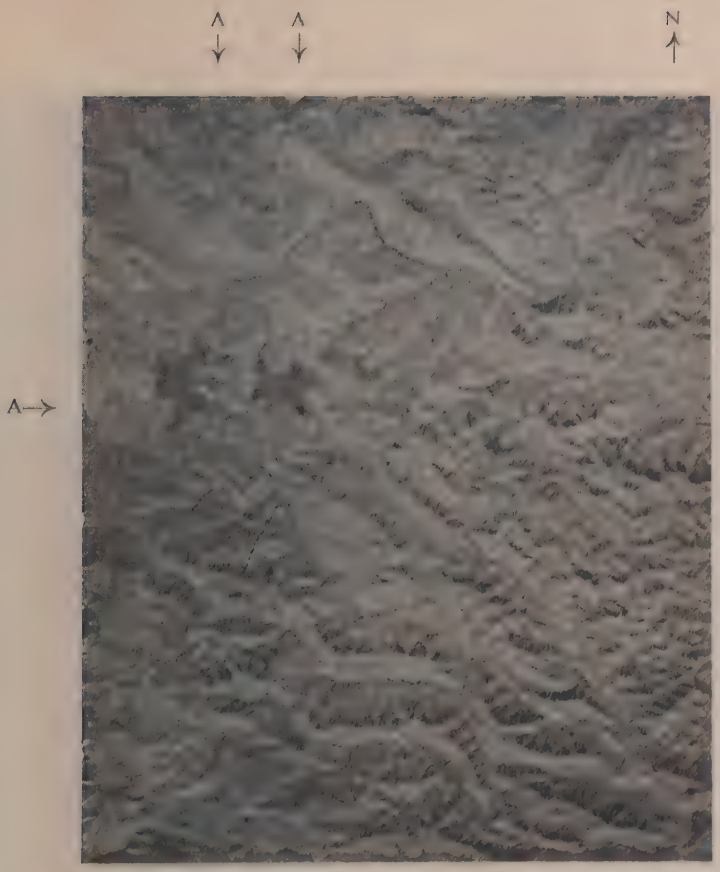


Figure 3

Typical badland morphology; Maestrichtian-Danian
(AA) — Dark spots representing Neogene conglomerates (Hush series) lying on hill tops unconformably on Danian.

Hathrurim region

Figure 4

Cenomanian landscape
Note bold wadi bands (AA) and (BB), waterfalls in wadi course.
Near Nahal Ramon

Figure 5

Turonian landscape
(AA) — Waterfall in water course.

Near Nahal Ramon

N

Figure 6

Pre-Cambrian Outcrops

The dark area represents isolated outcrop of Pre-Cambrian crystalline rocks surrounded by lighter-coloured young gravels. Note the distinctness of the boundary between the two formations.

Abu Darib Massif, Eilath area

Figure 7

Wadi Raman cirque

(AA) — Part of the Raman cliff, 250 m high. west of it: Cenomanian area, characterised by boldly curved large wadis; east of it: Lower Cretaceous Nubian Sandstone, showing numerous small crenulated wadi courses.

(BB) — Black area: Part of the Uppermost Jurassic lava-flows.

(CC) — Grey bands: Marine Upper Jurassic beds.

Nahal Ramon

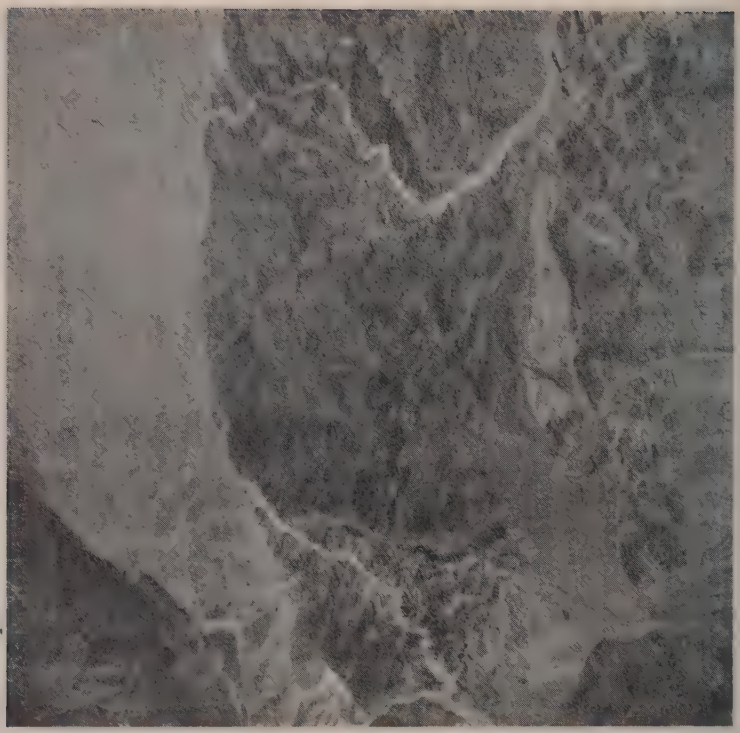


Figure 8

Fault pattern

Dark-grey finely dissected area in eastern half and in south-west corner of photo: Pre-Cambrian crystalline rocks. Light-grey areas in western part of photo and small area marked AA: sunken down blocks of Cenomanian Limestone. Note sharpness of fault lines.

Eilath area

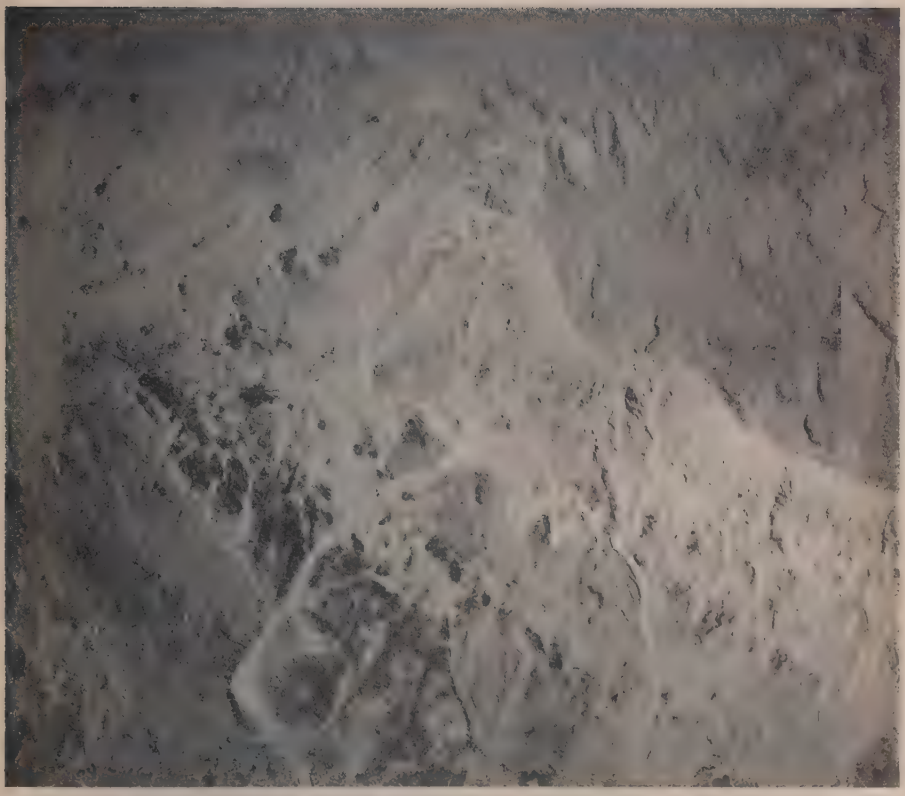


Figure 9

Nubian Sandstone

In the north-east part of the photo, part of the Raman cliff is visible: the area above it is composed of Cenomanian dolomites and limestones. All other parts of the photo show Nubian Sandstone areas. Note the row of dark spots within the sandstone underneath the bending cliff and parallel to it; they represent ferrugineous sandstones.

North-east part of Raman cirque

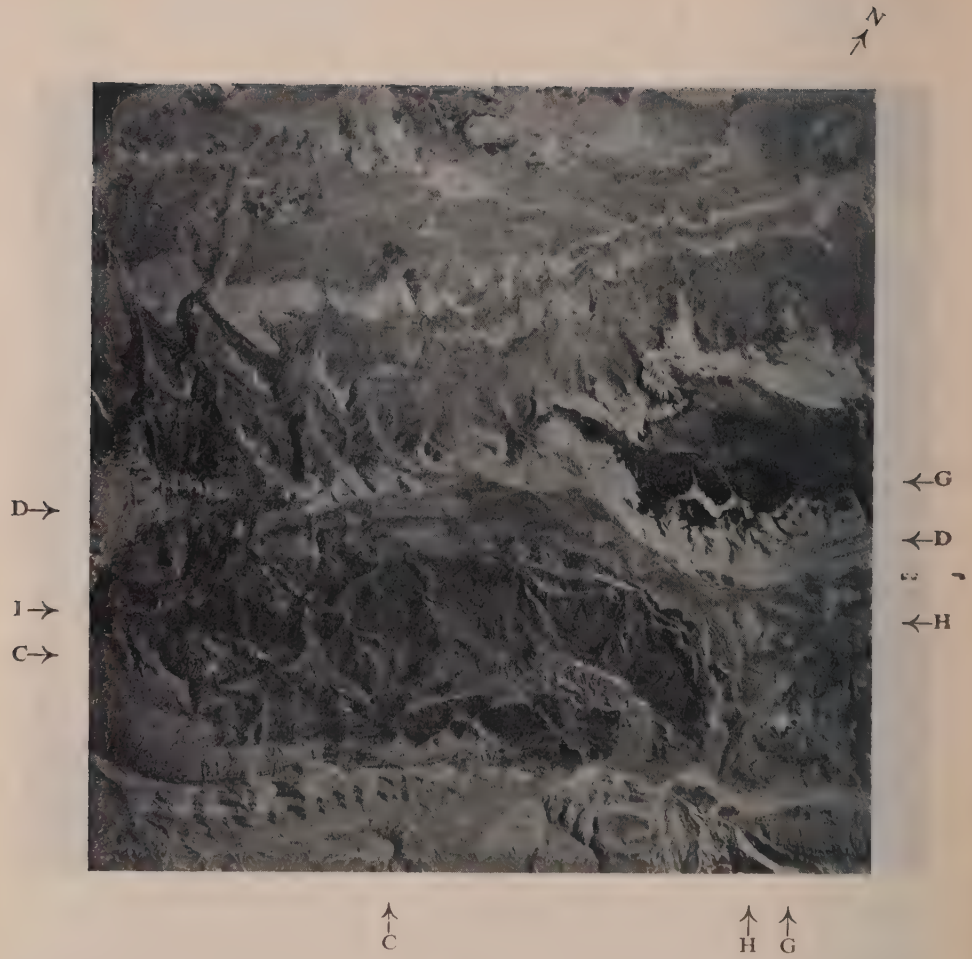


Figure 10

Triassic area
For explanation see also Figure 2
(GG) — Dark area: laccolith intruded into Triassic Gypsum.
(HH) — Triangular-shaped light-grey area built up of gypsum covered by limestone scree
(I) Small fault
Note the elliptical dome, the core of which is marked CC; the always outwards trending dips are clearly visible.

Core of Raman anticline

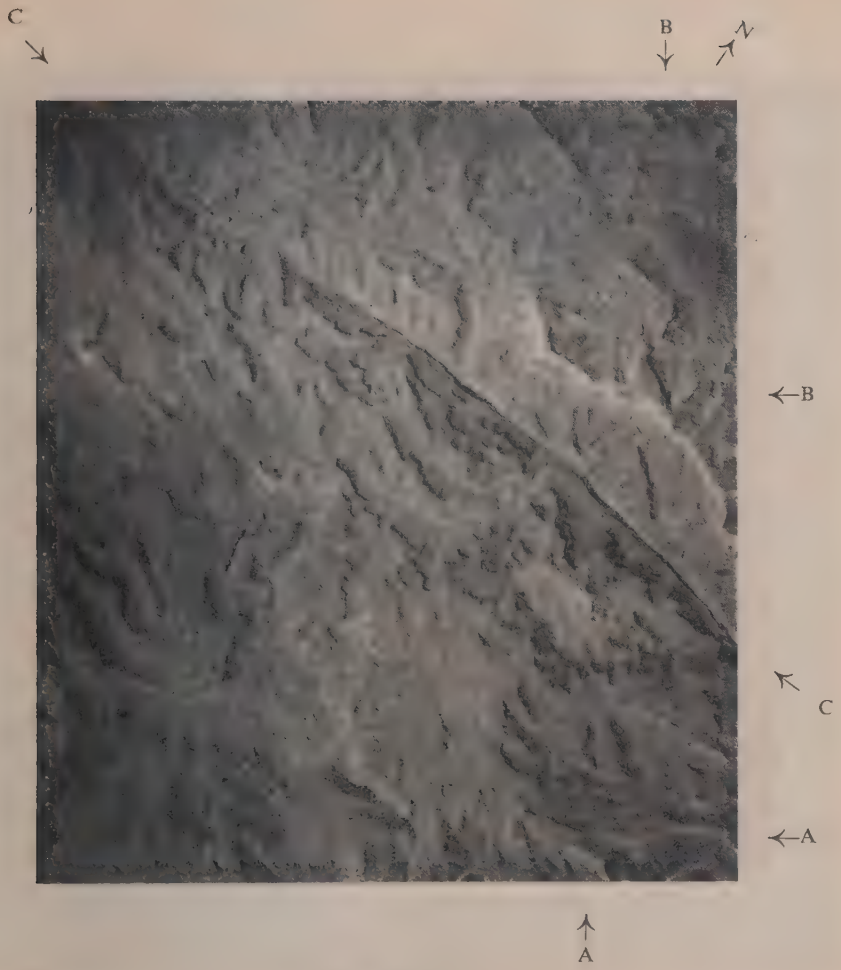


Figure 11

Typical Cenomanian landscape
(AA) and (BB) — Table-like Turonian remnants.
(CC) — Fault.

North of Wadi Raman

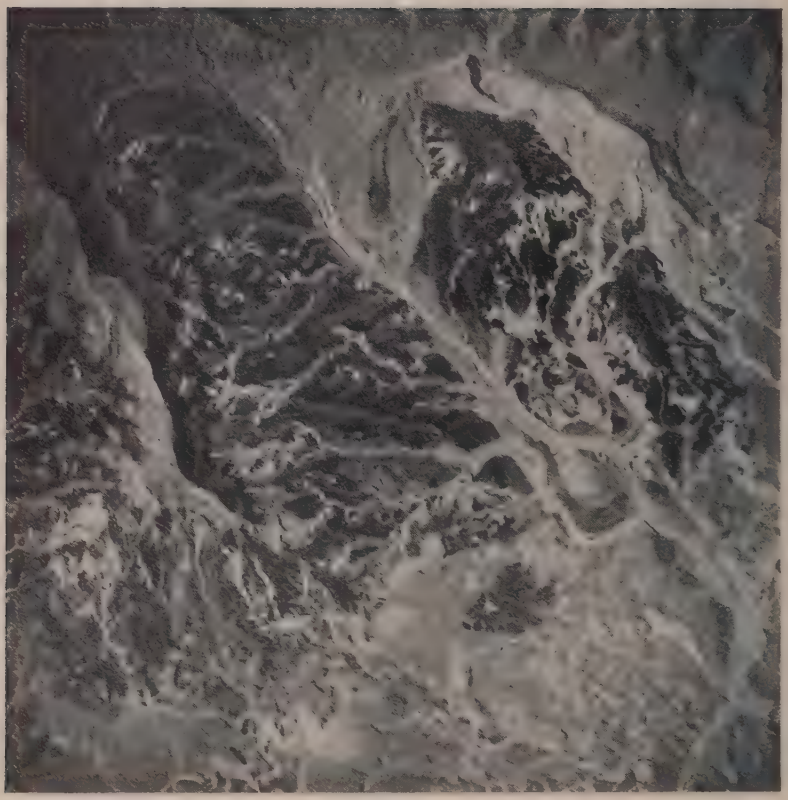


Figure 12

Characteristic Senonian strata
White: Santonian chalk overlain by black Campanian flint. The chalk is mainly exposed along the numerous small wadi courses.

Near Wadi Raman

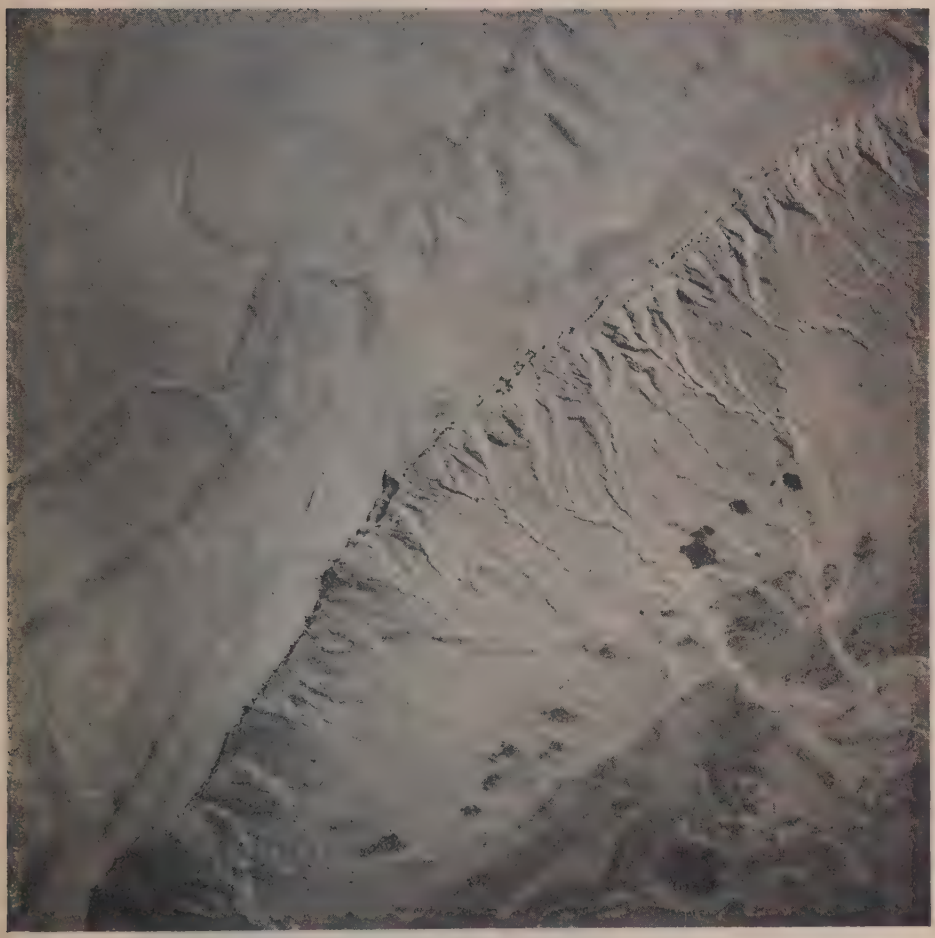


Figure 13

Isolated Outcrops

For explanation see also Figure 7. Note the row of dark spots underneath and parallel to the cliff markedAA representing Jurassic lava-flows partly covered by scree.

Raman cirque

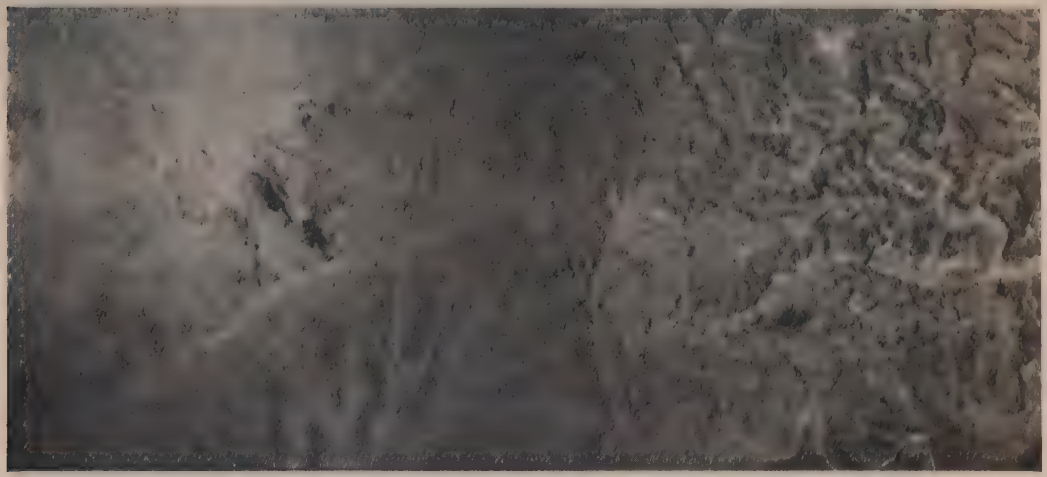


Figure 14

Isolated Outcrops
The north-east end of the Raman cirque is visible in the lower left part of the photo. Dark spots marked AA and BB are Cenomanian quartzolith.

Raman cirque

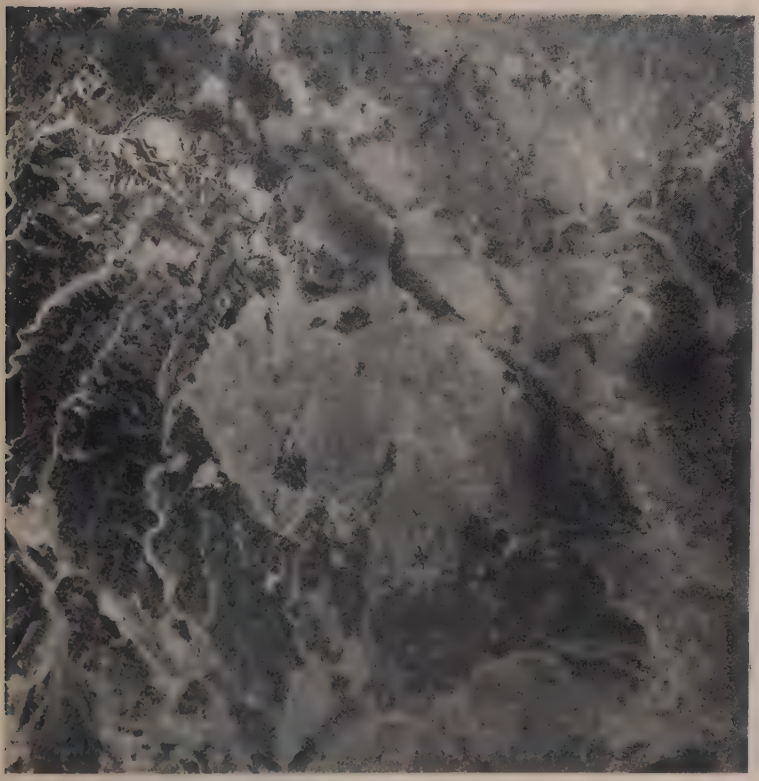


Figure 15

Tectonic dome

The elliptically shaped light-grey area near centre of photo is the tectonic Ras el Jeib dome, showing Turonian strata. The dome is surrounded by Senonian strata (black-white pattern). Remnants of black Campanian flint are visible overlying Turonian limestone.

Ras el Jeib anticline

Figure 16

Large fault line

West end of Raman cirque; dark areas within the cirque: Jurassic basalts. Light-grey areas outside the cirque: Cenomanian limestone; black-white pattern near lower margin of photo: Senonian chalks and flints. (AA) — Fault, breaching the cliff.

Raman cirque

ON THE IDENTITY OF *RHIPICEPHALUS SANGUINEUS* LAT

B. FELDMAN-MUHSAM
Department of Parasitology, Hebrew University, Jerusalem

Although *Rhipicephalus sanguineus* Lat. has been referred to in the literature for the last 150 years and studied for the last 40-50 years, its diagnosis has been confusing. We divide this cosmopolitan tick into 2 distinct species. The only difference we have been able to detect is in the female genital aperture; larvae and nymphs of the two species are readily distinguished by the contour of their anterior ends.

R. sanguineus Lat. s. l. is a proved carrier of important diseases to man and animals. It s obviously necessary to re-evaluate transmission experiments recorded in the literature in view of the fact that two distinct species can now be distinguished by morphological characters described in this paper.

Among the genera of *Ixodidae*, *Rhipicephalus* and *Hyalomma* are the most difficult for the systematist because distinct diagnostic taxonomic characters are few and because of considerable variation within a single species. This accounts for conflicting descriptions and diagnoses by different workers.

The genus *Rhipicephalus* is very widespread in the Old World, especially in Africa, where G. Theiler (1947)[1] mentions 38 species. The specific diagnosis of the genotype *R. sanguineus* Lat. is not less difficult than the classification of the whole genus. This species has been the subject of much speculation during the last 40–50 years. Many investigators established new species very closely related to *R. sanguineus*, and others have put these new species into synonymy. Neumann (1911)[2] had divided *R. sanguineus* into 3 subspecies: (1) *R. sanguineus sanguineus;* (2) *R. sanguineus punctatissimus*, Gerst.; (3) *R. sanguineus brevicollis* Neum. and had put Koch's species *R. rutilus*, *R. limbatus* and *R. siculus* into synonymy with *R. sanguineus sanguineus*. Zumpt put *R. punctatissimus* Gerst., which Neumann had accepted as a subspecies, into synonymy with *R. sanguineus* Lat.* Banks (1908)[3] introduced the name *R. texanus* for the North American *R. sanguineus*. Recent authors, Bequaert (1946)[4], Cooley (1946)[5], have put *R. texanus* into synonymy with *R. sanguineus* Lat. Yakimoff and Kohl-Yakimoff (1911)[6] described *R. rossicus* from the Ukraine. *R. rossicus* is very closely related to *R. sanguineus* s.l. Olenev (1931)[7] did not recognize this species while Zumpt (1939)[8] on the other hand accepted *R. rossicus* as a subspecies of *R. sanguineus*.** *R. schulzei* Olenev is considered by Zumpt (1940)[9] to be a subspecies of *R. sanguineus* Lat. Schulze (1935)[10] described a new species, *R. pumilio*, which is very similar to *R. schulzei*. *R. pumilio* is considered by Zumpt (1939) to be a synonym of *R. sanguineus schulzei*. Pomeranzev (1946)[11] accepted both *R. pumilio* and *R. schulzei* as valid species.

The characters which serve for diagnosis of species in the genus *Rhipicephalus* are:

* All the material of Koch and Gerstäcker was mounted on pins and in most instances the genital aperture was damaged. As a result the only type specimen which could be examined by our method is *R. punctatissimus* Gerst. This species was found to be identical with *R. sanguineus* Lat. s. str.

** A study of the female genital aperture of the co-type of *R. rossicus* convinced us that *R. rossicus* is distinct from *R. sanguineus* Lat. s. l.

Received June 1952

the form of the eyes, the punctation of the scutum, the form of the anal plates, of the first coxae and of the stigma in the males. The form of the eyes, the form and punctation of the scutum and the form of the stigma in the females. Most of these characters have been shown to be very unstable and variable. Nuttall (1913)[12] and Cunliffe (1914)[13] proved this by breeding of *R. appendiculatus* and *R. sanguineus*, and Zumpt by comparing large numbers of ticks from the same locality.

Since 1946, when Adler and Feldman-Muhsam[14,15] published their first report on a new method of classification which they established for *Hyalomma*, it was possible to clear up some ambiguities in the systematics of other *Ixodidae*, as the method subsequently proved useful for the genera *Dermacentor* and *Amblyomma* 1951[16], for *Haemaphysalis* (1950)[17] and for *Rhipicephalus*.

On the basis of this method, we could establish that what is generally called *R. sanguineus* is not one species but actually two. The usualm ethod of classification, i.e. the examination of macroscopic external characters is not sufficient for distinguishing between these two species. The genital aperture of the female is the only character which so far definitely distinguishes between the females of the two species. In addition, the larvae and nymphs of these two species are easily distinguished by other characteristics.

Unfortunately it is impossible to state at this moment which of the two species is actually *R. sanguineus* Lat. This can be determined only after examining the genital aperture of the type specimen, but so far we have not been able to trace it. There is no indication as to where the type, if it exists, can be located. Further more in the literature the type is referred to (Bequaert 1946)[4] as "No sex, France, no host". And it is doubtful if this point can ever be settled. Under these circumstances we apply the name *R. sanguineus* Lat. to the species most prevalent on the dog because the dog has generally been considered to be the commonest host of *R. sanguineus*. To the second species we apply the name *R. secundus*

DESCRIPTION OF SPECIES

The following description of the larvae, nymphs and imagines of the two species is based on laboratory-bred ticks. It should be pointed out that the observations were based on examination of laboratory-bred specimens in all stages of development. The offspring of six wild females were examined from larvae to imagines and in addition the larvae from tens of females were also studied. In all cases the genital apertures of laboratory bred adult females bred "true" and the larvae and imagines were consistently characteristic.

The description of larvae and nymphs of *R. sanguineus* in the literature is incomplete. Cunliffe (1914)[13] in a study of the variation in adult *R. sanguineus* gave drawings but no description of larvae and nymphs which correpond to *R. sanguineus* s.str. Bedford's (1934)[18] drawing of a larva corresponds to *R. sanguineus* s. str., but is not accompanied by a description. (It is included in a key to the South African species). Cooley's (1946)[3] drawings and descriptions of the larvae and nymphs are those of *R. sanguineus* s. str.

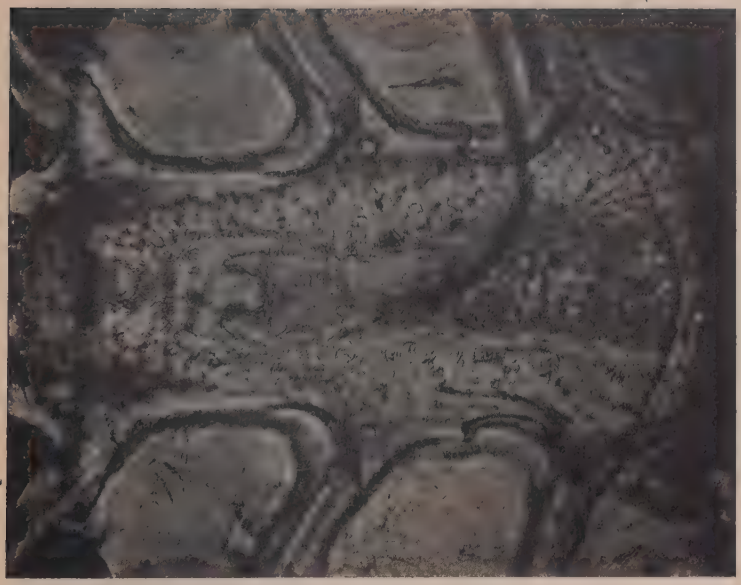


Figure 1
R. sanguineus Lat. s. str. Female genital aperture (x110)

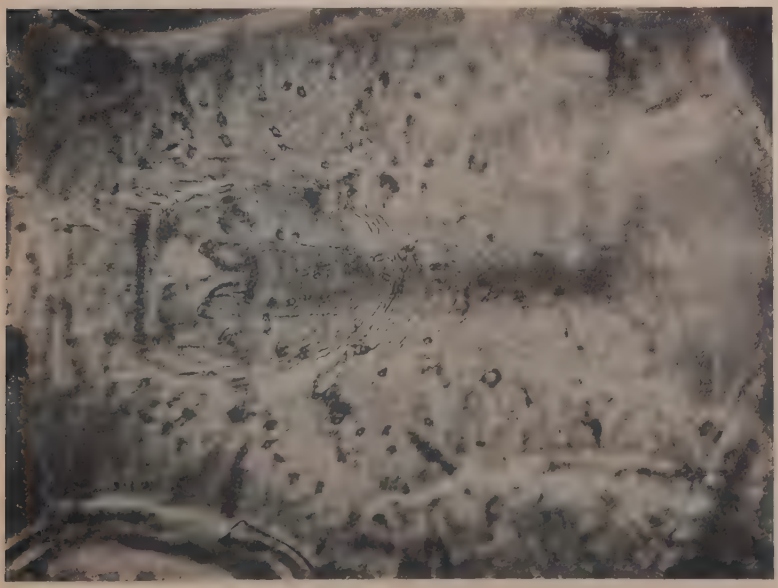


Figure 5
R. secundus n. sp. Female genital aperture (x110)

Figure 7
Larva of *R. sanguineus* Lat. s. str. (x 150)

Figure 8
Larva of *R. secundus* n. sp. (x 150)

Rhipicephalus sanguineus Lat. s. str.

Male: We have not been able to find any distinguishing characters between the males of the two species and therefore have nothing to add to current descriptions (1946)[5] of the imagines.

Female: The only difference which we found between the two species is the form of the genital aperture. The genital aperture has the form of a large round cup widely open upwards. The flaps become thinner progressively; the aperture of the cup is wider than the distal tube (Figure 1).

Figure 2

R. sanguineus nymph A) Capitulum dorsum B) Capitulum venter

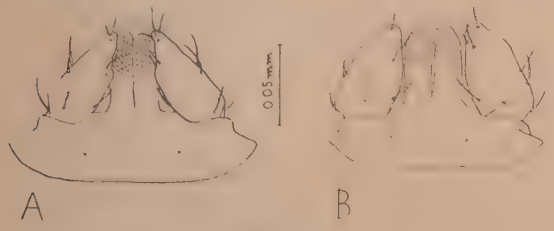


Figure 3

Capitulum, larva A) *R. secundus*, B) *R. sanguineus* s. str.

Nymph: Body — long oval. Scutum is as long as broad. Eyes are on the lateral corners of the scutum. Lateral border of the basis capituli has two acute angles (Figure 2) First article of the palp bears ventrally a long, stout hair which is branched on one side (Figure 2B). Dentition of the hypostome 2/2 with 7—8 teeth per file. Coxa I with two long spurs. Coxae II and III with one very short spur. Coxa IV without a spur. Dorsal fovae contain 2—3 elements.

Larva: Body — oval. Length of the scutum from the middle of the line joining the tips of the scapulae to the posterior margin is 0.19 — 0.21 mm. Eyes are on the lateral corners of the scutum.

The basis capituli is only very sligthly wider than the maximum distance between the most lateral points of the two palps. This distance exceeds considerably the width of the anterior part of the basis capituli. The width of the basis capituli is 0.13—0.14 mm. The external aspect of the palp is salient laterally. The upper external line of the palp is convex externally (Figure 3B). Dentition of the hypostome 2/2, 5—6 teeth per file.

There are short spurs on all coxae. There are four pairs of non-functional spiracles as in *Hyalomma* (1948)[19], three posterior to the coxae and the fourth on the dorsal side near the posterior edge of the body.

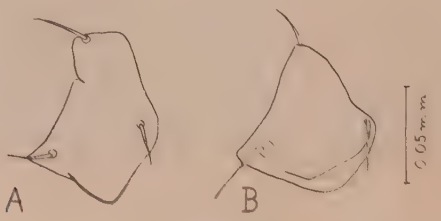


Figure 4
1 st. coxa of larva A) *R. secundus* B) *R. sanguineus*

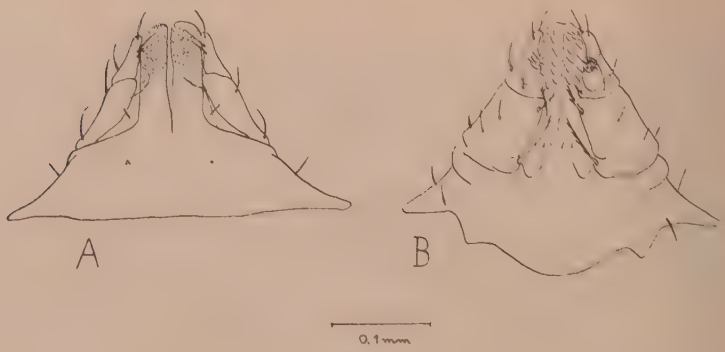


Figure 6
R. secundus sp. n. nymph A) Capitulum dorsum B) Capitulum venter

Rhipicephalus secundus n. sp.

Female: In *R. secundus* the cup of the genital aperture is less round and less wide than in *R. sanguineus* s. str. The cup is only very slightly wider or almost the same width as the upper portion of the underlying tube. The inner opening of the cup is much narrower in *R. secundus* than in *R. sanguineus* s. str. (Figure 5).

Nymph: Body—long oval. Scutum similar to that of *R. sanguineus*. The two lateral angles of the basis capituli are very acute (more than in *R. sanguineus*), and bear a hair on their anterior aspect. Palps are very slender and meet at an acute angle. The

hair on the ventral side of article one of the palp is similar to that of *R. sanguineus* but thinner (Figures 6A and B). Dentition of the hypostome is 2/2 with 7-8 teeth per file. Coxae as in *R. sanguineus* s. str.

Larva: Body—oval. Length of the scutum from the middle of the line joining the tips of the scapulae to the posterior margin is 0.19—0.2 mm. Eyes on the lateral corners of the scutum. Width of the basis capituli is 0.15 mm and is much wider than the distance between the most lateral points of the palps. This distance is even smaller than the width of the anterior part of the basis capituli. The upper external line of the palp forms a straight line and is not convex externally as in *R. sanguineus* s. str. (Figure 3A). Dentition of the hypostome is 2/2; 5—6 teeth per file. Coxa I with a medium spur (Figure 4A). Coxae II and III with very slight spurs. Spiracles as in *R. sanguineus* s. str.

The difference in the character of the palps of the larvae are readily distinguished between the two species (Figures 3, 7, and 8). The anterior part of the larva of *R. secundus* is more pointed than that of *R. sanguineus* s. str.

CONCLUSIONS

Examinations of specimens of *R. sanguineus* s. l. from different parts of the world showed that the two species: *R. sanguineus* s. str. and *R. secundus* n. sp. are present in many places. The small collection of ticks that we examined from different localities showed that the two species are present in France (9 females) and Algeria (10 females). A lot (4 females) from Genoa, Italy, and one lot (5 females) from Cheribon, Indonesia, were exclusively *R. sanguineus* s. str. It is worthwhile to note that 5 lots (19 females) from different places in the U.S.A. were uniformly *R. sanguineus* Lat. s. str. In view of the fact that *R. sanguineus* was introduced relatively recently into the New World, it would be of prime interest to know whether *R. secundus* is absent from America.

It should be mentioned that *R. sanguineus* Lat. s. l. has been implicated as a carrier of many different diseases to animals, especially to the dog which is its most important host, and to man. It is a known transmitter of fievre boutonneuse to man and *Babesia canis* to the dog. Parker and his collaborators (1932)[20] showed that although *R. sanguineus* Lat. (s. l.) is not a natural vector of the Rocky Mountain spotted fever and of tularemia it is able to transmit both diseases in the laboratory. *R. sanguineus* Lat. (s. l.) was reported by Sergent (1933)[21] to transmit *Spirochaeta hispanica*.

In view of our findings that *R. sanguineus* Lat. s. l. is not one but two distinct species, it is obviously necessary to re-evaluate all transmission experiments made with *R. sanguineus* Lat. and recorded in the literature.

SUMMARY

R. sanguineus Lat. s. l. is divided into 2 species: *R. sanguineus* Lat. s. str. and *R. secundus* n. sp. The imagines are distinguished only by the female genital aperture. The larvae and nymphs are easily distinguished by the form of the capitulum.

ACKNOWLEDGMENT

We wish to thank Dr. J. Bequaert from the Museum of Comparative Zoology, Cambridge, Mass., U.S.A., Dr. A. G. Chabaud, from the Institut de Parasitologie de Paris, Dr. D. Guiglia from the Museo Civico di Storia Naturale, Genoa, Italy, Mr. L. van der Hammen from the Rijksmuseum van Naturlijke Historie, Amsterdam, Holland, Dr. G. M. Kohls, from the Rocky Mountain Laboratory, U.S.A., Prof. Ed. Sergent, from Institut Pasteur d'Algérie, and J. Théodoridès, Attaché de Recherches au C.N.R.S., France, for the gift of specimens, as well as to Dr. Evans from the British Museum and Prof. Kestner from the Zoologisches Museum, Berlin, for their kind permission to study the type specimens.

REFERENCES

1. Theiler, G., 1947, *Onderstp. Journ. Vet. Scien. Anim. Indus.*, **21**, 253.
2. Neumann, L. G., 1911, *Ixodidae:* In *Das Tierreich*, Berlin, 26, Lief.
3. Banks, N., 1908, U. S. Dept. Agric. Bureau of Entomol. Tech. series, No. 15.
4. Bequaert, J. C., 1946, *Entomologica Americana*, **25**, 73.
5. Cooley, R. A., 1946, Nat. Inst. of Health, Bull. No. 187.
6. Yakimoff, W. L. and Kohl-Yakimoff, N., 1911, *Arch. Parasitenkde.*, **14**, 416.
7. Olenev, N. O., 1931, *Z. Parasitenkde.*, **4**, 126.
8. Zumpt, F., 1939, *Z. Parasitenkde.*, **11**, 400.
9. Zumpt, F., 1940, *Z. Parasitenkde.*, **11**, 669.
10. Schulze, P., 1935, *Wiss. Erg. Nied. Exp. Karakorum*, 178.
11. Pomeranzev, B. I., 1946, *Ins. Zool. Acad. Scien.*, U. S. S. R.
12. Nuttall, G. H. F., 1913, *Parasitology*, **4**, 195.
13. Cunliffe, N., 1914, *Parasitology*, **6**, 372.
14. Adler, S. and Feldman-Muhsam, B., 1946, *Refuah Veterinarith*, **3**, 9.
15. Adler, S. and Feldman-Muhsam, B., 1948, *Parasitology*, **39**, 95.
16. Feldman-Muhsam, B., 1951, *Bull. Res. Counc. of Israel*, **1**, No. 1-2, 164.
17. Feldman-Muhsam, B., 1951, *Bull. Res. Counc. of Israel*, **1**, No. 3, 96.
18. Bedford, G. A. H., 1934, *Onderstp. Jour. Vet. Scien. Anim. Indus.*, **2**, 49.
19. Feldman-Muhsam, B., 1948, *Parasitology*, **39**, 140.
20. Parker, R. R. Philip, C. B. Davis, G. E. and Cooley, R. A., 1937, *J. Econ. Entom.*, **30**, 51.
21. Sergent, A., 1933, *Compt. Rend. Acad. Sci.*, **197**, 717.

LETTERS TO THE EDITOR

The Editorial Board does not accept responsibility for the views expressed in the letters printed below.

A SEARCH FOR THE NATURAL RADIOACTIVITY OF VANADIUM

In recent years, Hess and Inghram[1], and also Leland[2], working with mass spectrometers, discovered a naturally occurring isotope of vanadium with mass number 50 ($_{23}V^{50}$), and of particularly low relative abundance (0.25%). This discovery establishes the existence of a hitherto unknown triplet of neighbouring isobaric nuclei (i.e. nuclei with the same mass number), since $_{23}V^{50}$ is isobaric with the corresponding isotopes of chromium and titanium, $_{24}Cr^{50}$ and $_{22}Ti^{50}$ (relative abundances 4.5% and 5.4% respectively). According to well known reasoning, two neighbouring isobaric nuclei cannot both be absolutely stable against radioactive decay, although in the case of naturally occurring isotopes, the half-life for decay must be very long. It is therefore of interest to examine the three above-meutioned elements for natural radioactivity. In view of the rather attractive hypothesis that the possible natural decay of V^{50} (either by β-decay to Cr^{50} or by orbital electron capture to Ti^{50}) during geological history ($\sim 3 \times 10^9$ years) might explain its very low abundance, the element vanadium has been examined first.

Earlier measurements carried out in this laboratory[3] had already shown that the half-life for decay of V^{50} to Ti^{50} by K-capture must be greater than 10^{10} years. The following experiments were carried out with much more sensitive apparatus and with which possible β-decay of V^{50} to Cr^{50} might also be detected.

A screen-wall Geiger counter (of the type used by Libby[4]) was used, and this included sliding outer cathodes on which materials to be examined could be deposited. A positive electrostatic field between the screen-wall and the outer cathode enabled ions produced in this region to be dragged into the effective counting region and thus ensure approximately 2π collection. About 5 grams of highly pure vanadium oxide (V_2O_5) was ground very fine, mixed into a paste with water and a little agar-agar, and spread uniformly over 300 sq.cm of aluminium foil; when dry, this was inserted in the counter to form one of the outer cathodes. An argon alcohol filling was used. The counter was shielded with iron and lead, and showed a background counting-rate of 155/minute.

No statistically significant increase in the counting rate was observed after introduction of the vanadium oxide, and it was concluded that the number of counts produced by the vanadium sample must be less than 2/minute. From this result, lower limits for the half-life of decay of V^{50} can be estimated. For the decay of V^{50} to Ti^{50} by K-capture, taking into account the fluorescent yield of the K X-rays of titanium which would follow K-capture, the counter efficiency for these X-rays and also their self-absorbtion in the vanadium oxide, one concludes that the half-life must be greater than 10^{12} years. If one excludes the unlikely possibility that the maximum energy of the β-particles in the possible β-decay of V^{50} to Cr^{50} is less than about 50 kev, one obtains, similarly, the same approximate lower limit for the half-life of this latter process.

It is hoped in the near future to examine in a similar manner samples of titanium and chromium and also to increase the sensitivity using anti-coincidence shielding. The above results already show, however, that the possible natural decay of V^{50} cannot account for its low relative abundance, since its half-life must be at least two orders of magnitute greater than the age of the earth.

S. G. COHEN
R. BAUMINGER
Department of Physics, Hebrew University, Jerusalem.

REFERENCES

1. HESS, D. C. and INGHRAM, M. G. 1949, *Phys. Rev.* **76**, 1717.
2. LELAND, W., 1949, *Phys. Rev.* **76**, 1722.
3. CARMI, D., 1950, MSc. Thesis.
4. LIBBY, W. F., 1934, *Phys. Rev.* **46**, 196

Received August 1952

THE COLLECTION OF SAND AND DUST CARRIED IN THE ATMOSPHERE

In order to draw conclusions regarding the transporting capacity of the local atmosphere for various dusts and vapours, a survey of wind-suspended natural aeolian matter was carried out during the latter years of the second world war. The measurements, taken in the Beersheba loess region of Israel, also have significance with respect to the estimation of the annual deposition of soil-building material.

A. THEORY

The fundamental concept in sedimentation theory is a steady settling velocity, w, for particles when settling in a fluid at rest.

When the fluid medium is in a state of motion—smoothly flowing or irregularly agitated—the steady downward movement of a suspended particle becomes superimposed on the movements of the surrounding fluid element. The particles are kept in suspension, against their tendency to settle onto the ground, by the irregular vertical velocity components of the fluid's motion. *Vectorially*, these turbulent velocity components cancel out over a period of time, yet the average of their *absolute* values, v, is an important measure of the fluid's state of turbulence:

$$\Sigma v = 0; \quad v = \bar{v}$$

To express the random motions of the particles in a turbulent fluid in the form of an "eddy-diffusion coefficient" (forced diffusion), v must be multiplied by a length $\bar{l}$ called the "mean mixing length". The physical meaning of $\bar{l}$ can be interpreted as the average diameter of fluid pockets or eddies which move through the turbulent fluid causing the velocity fluctuations and the forced diffusion of suspended matter. In a flowing fluid l is small near the boundaries (which, in our case, is the ground) and becomes proportionally larger with greater distance from the boundary (in our case, the height, h, above the ground). This proportionality was discovered by Theodore von Karman, who also found that the proportionality factor between l and h is universal for all fluids and for all types of motion. Its value is 0.4 and it is known as the von Karman constant. For fluids of non-homogeneous density, like an unequally heated atmosphere, any value, $\pm$ 50 % of this constant may apply, depending on the thermal structure of the air. Consequently, the eddy-diffusion coefficient (forced diffusion coefficient) for flowing air may be written with sufficient accuracy.

$$D = \bar{l} \cdot v = 0.4 \cdot h \cdot \bar{v}.$$

On multiplying this value by the height gradient of suspended material, dn/dh (n denotes the number of particles contained in a unit volume of air), we get the net number of particles lifted each unit time across a certain level h. At kinetic equilibrium, this number is exactly counterbalanced by the number of particles settling down across h during the same time period. Assuming w to represent the settling velocity of all particles, we can then set up the differential equation

$$0.4 \cdot h \cdot v \cdot dn\,dh = -n \cdot w,$$

which on integration gives

$$n = C \cdot (1/h)^{w/0.4\bar{v}}$$

(C being the integration constant).

If we attempt to calculate the relative number of particles travelling above and below an arbitrary height, H, we find the ratio of the two, a/b, to be, formally.

$$a/b = \int_H^\infty (1/h)^{w/0.4\bar{v}} dh \;\Big/\; \int_0^H (1/h)^{w/0.4\bar{v}} dh$$

The fraction of the particles found at any time above or below h is.

$$F_a = 1/(1 + b/a) \quad \text{and} \quad F_b = 1/(1 + a/b).$$

If $w/0.4\bar{v} > 1$, the integrals in the expression for a/b exist. With growing H, a/b very quickly converges to zero so that practically all particles will belong to F_b and none to F_a. If, however, $w/0.4\bar{v} \leqslant 1$, a/b fails to converge to a finite value so that, with any finite H, principally all particles will be part of F_a. This means that particles whose settling velocity, w, is less than about a half to a quarter of the average turbulent velocity component in the atmosphere, $\bar{v}$, can travel almost indefinitely in the atmosphere without having to enter the ground-near layer. Particles whose settling velocity is greater than that, need "ground-support" for their transport, i.e. they must be intermittently deposited on the ground. Material, the coarseness of which exceeds this particular limit, can, therefore, travel only over ground the cover of which permits *reversible* deposition. Quantitative comparison of natural aeolian material at different heights in the atmosphere with the material accumulating on different types of ground can thus give indications regarding the mechanical structure of the atmosphere.

B. INSTRUMENTATION

It is impractical and, from our point of view, undesirable to determine the amount of atmosphere-carried material by filtering a given sample of air. The method of exposing gummed microscope slides in different positions is unreliable because: (1) a thin laminar flow layer develops next to the exposed surface, which layer is penetrated with unequal ease by particles of different size, and (2) the surface may be warmed by the sun thereby setting up disturbing instabilities in the immediately surrounding air.

A simple piece of apparatus which collects quantitatively significant samples of atmospheric dust was devised as follows: The lower end of a vertical glass tube was closed by a cork stopper onto which a tared circular microscope cover glass was placed. The upper end of the glass tube was left open. The theoretical performance of the apparatus is not interfered with if a small roof is set up some distance above its mouth to protect it against interference by birds and

insects. Such tubes were exposed singly and in bundles.

From the principle of vectorial additivity of settling velocity and turbulent velocity components, and from the fact that the latter cancel out over a period of time, it follows that the *net* rate of settling of dust particles is unaffected by turbulence. Therefore the rate of settling of any particular dust fraction into the tube's mouth is the same as is the rate of settling of this fraction at any level inside the tube. Neither can the relative concentrations of different dust fractions be affected by local turbulent mixing in or immediately above the collecting tube. In view of these equalities the rate of settling into the tube is determined by the rate of settling, in the lowest part of the tube, onto the receptor disc. If the tube is properly set up, so that no draft or eddies can penetrate to the lowest part and re-suspend the sediment on the disc, the total mass of dust collecting there, M, between the time t_1 and t_2 will be

$$M = S \sum_{i=1}^{j} \int_{t_1}^{t_2} n_{F_i} \, m_{F_i} \, w_{F_i} \, dt,$$

where S is the surface area of the receptor, j the (arbitrary) number of dust fractions, n_F the number, per unit volume of air, of the suspended particles belonging to one fraction, m_F the average mass of a particle belonging to a fraction, and w_F the uniform fall velocity of the particles in the fraction. It is seen that the amount of material thus collected represents the *maximum value of potential deposition* of material that can be carried across unfavourable ground. Actual deposition of such material on the ground is lower for two reasons: (1) atmospheric turbulence reaching right down to the ground continuously re-suspends from there part of the deposited material; (2) the tube catches also some of the material carried back and forth locally.

The values measured in the Beersheba loess region by exposing dust collection tubes at approximately five metres above ground, were of an unexpectedly small order of magnitude: 0.02 grams per square centimeter, integrated for the whole dry season of the year. This corresponds to an annual potential soil deposit of about 0.1 millimeter.

M. Rim,
Soil Science Department,
The Hebrew University,
Jerusalem.

REFERENCES

1. von Karman, Theodore, 1939, *Jour. Aeronautical Sciences* **1**, No. 1, 1.
2. von Karman, Theodore, 1947, *Technion Yearbook*, 52.

Received May 1952

ON THE SOLUBILITY OF SODIUM CHLORIDE IN DEAD SEA BRINES

The solubility of sodium chloride in Dead Sea brines is a determining factor in the manufacture of potassium chloride from a typical surface brine ($d_4^{27.5}$ 1.186) of the composition (in moles per 1000 moles of water): K_2Cl_2 1.49, Na_2Cl_2 13.9, $CaCl_2$ 6.41, $MgCl_2$ (including $MgBr_2$) 26.45, $CaSO_4$ 0.18.

Although the phase diagram of such solutions is not known, the solubility of sodium chloride in a brine of the above composition can be approximately calculated making the simplifying assumption that the calcium salts are considered as magnesium chloride (the concentration of which could then be 33.04 per 1000 moles of water), and that the relatively small quantity of potassium chloride is regarded as sodium chloride.

With the aid of the d'Ans diagram[1] for the system $NaCl$-$MgCl_2$-H_2O, the solubility of sodium chloride can then be calculated. If a horizontal line is drawn through the ordinate 33.04 moles of magnesium chloride, 26.2 moles of sodium chloride should be present at saturation (25° C). Deducting the 1.49 moles of potassium chloride, one arrives at a figure of 24.71 moles per 1000 moles of water for the solubility of sodium chloride in the brine.

For the present investigation, natural Dead Sea brines and mixtures of such brines as well as artificially prepared solutions were saturated with sodium chloride at different temperatures, and analysed. All ions were determined directly, except magnesium which was calculated by difference. The bromide in the Dead Sea water was determined as magnesium chloride, the error introduced being insignificant.

Since the composition of the brine varies with place and season, the synthetic brines were prepared so as to represent also solutions which have not occurred in the past two years in the southern region of the Dead Sea, from where the natural brines were taken. In preparing these solutions, the presence of manganese, rubidium and carbonate ions, known to occur in negligible amounts in the Dead Sea, was neglected.

The specific gravity of the solutions saturated with NaCl investigated varied between $d_4^{27.5}$ 1.215 and 1.225. It was thus possible to determine the influence of increasing concentrations of magnesium chloride and other salts on the solubility of sodium chloride. The results are given in Table I.

The average value of the temperature gradient of the solubility of sodium chloride in the range studied is 0.05 moles per 1000 moles water per degree. Less concentrated brines seem to have a slightly higher gradient. This observation is of practical importance.

TABLE I

Solubility of sodium chloride in salt solution
(Moles in 1000 moles of water)

Sample	Temp.	Specific Gravity of original Solution (27.5°/4°)	Specific Gravity after saturation	Na_2Cl_2 in original brine	Na_2Cl_2 after saturation	K_2Cl_2*	$CaCl_2$*	$MgCl_2$*	$CaSO_4$*
1	20° C	1.185	(27.5°/4°) 1.215	13.85	24.60	1.49	6.27	26.90	0.17
			(27.5°/4°)						
1		1.185	1.223	13.85	25.20	1.49	6.42	26.80	0.17
2		1.194	1.222	14.64	23.22	1.52	6.79	28.98	0.18
3		1.196	1.222	15.40	23.55	1.55	6.76	27.90	0.19
4	27.5° C	1.175	1.218	13.24	26.60	1.46	6.34	25.20	0.17
5		1.186	1.218	14.04	25.10	1.51	6.54	27.03	0.18
6		1.190	1.225	15.02	24.51	1.59	6.98	28.20	0.19
7		1.202	1.220	15.70	23.00	1.68	7.16	29.50	0.21
			(35° 4°)						
1		1.185	1.220	13.85	25.68	1.47	6.24	26.60	0.17
2		1.194	1.217	14.64	24.20	1.50	6.56	28.30	0.17
4	35° C	1.175	1.220	13.24	27.55	1.47	6.30	25.20	0.17
5		1.186	1.218	14.04	25.40	1.53	6.55	27.10	0.18
6		1.190	1.222	15.02	24.90	1.51	6.68	27.55	0.19
7		1.202	1.221	15.70	23.60	1.60	7.02	29.25	0.19
8		1.193	1.221	15.13	24.65	1.54	6.81	27.83	0.19
			(50°/4°)						
4		1.175	1.212	13.24	28.30	1.55	6.14	25.88	0.18
5	50° C	1.186	1.215	14.04	25.85	1.54	6.54	27.13	0.18
7		1.202	1.217	15.70	24.10	1.62	6.94	28.98	0.19
8		1.193	1.215	15.13	25.60	1.52	6.86	28.60	0.19

* before and after saturation with sodium chloride

Table II gives actual figures for the solubility of sodium chloride in Dead Sea brine and shows the temperature coefficient of the solubility for Dead Sea brines of two different concentrations.

TABLE II

Temperature coefficient of the solubility of sodium chloride in natural Dead Sea brine

	g NaCl dissolved in 1 liter of brine	
Temperature	at $d_4^{27.5}$ 1.175	at $d_4^{27.5}$ 1.186
27.5° C	80.5	66.1
35° C	86.2	67.6
50° C	90.5	70.4

I. SCHNERB
F. YARON
Research Council of Israel

REFERENCE

1. D'ANS, J., 1933, *Die Loslichkeitsgleichgewichte der Systeme der Salze ozeanischer Salzablagerungen.* Berlin, Table IV, Figure 1.

Received April 1952

THE REACTIVITY OF THE *α*-HYDROGEN IN *α*-AMINO ACID ESTERS

The observation that ethyl glycinate undergoes an aldol-type condensation with reactive aromatic aldehydes[1,2,3]:

$$NH_2.CH_2.COOR + Ar.CHO \rightarrow NH_2.CH(CHOH.Ar).COOR$$

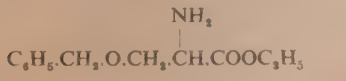
reveals an unexpected reactivity of the methylene group. Indeed, a closer analysis of the reaction has shown that the reacting species is not the *α*-amino-ester, but its N-benzylidene-derivative; the system

$$\begin{matrix} CH_2{-}N = C \\ \quad\quad\quad\quad | \\ \quad\quad\quad\quad X \end{matrix}$$

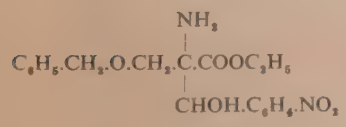
has been known to exhibit "methylenic activity" in more complex cases[4].

It has now been found that even without this initial activation by Schiff base formation, α-amino esters are capable of aldol condensation with *p*-nitrobenzaldehyde, if their α-hydrogen atom is activated photochemically. Whilst, e.g., ethyl sarcosinate[2] or *O*-benzyl-serinate do not react with the aldehyde under the conditions under which ethyl glycinate undergoes the above condensation, reaction takes place when the mixtures are exposed to ultraviolet light (sunlight in quartz vessels).

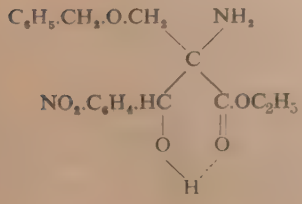
(i) Ethyl *O*-benzyl-serinate (I), obtained in analogy with the preparation of the *O*-ethyl-serine ester[5], gives with *p*-nitro-benzaldehyde in methanolic solution a product, crystallizing from isopropyl alcohol in colourless prisms, m.p. 136°. Analysis shows that formula (II) represents the structure of the product; also the infrared spectrum proves that the amino group has remained unattacked. The shift of the hydroxyl absorption to 3075 cm^{-1} reveals strong hydrogen bonding, perhaps according to (III). *Anal.* Calcd. for $C_{19}H_{22}O_6N_2$: C,61.0; H,5.9 N,7.5; OC_2H_5,12.0; amino-N, 3.7; mol.wt., 374. Found: C,61.2; H,5.7; N,7.5; OC_2H_5, 12.0; amino-N, 3.7; mol.wt., 350 (in boiling benzene). (ii) Ethyl sarcosinate (IV) and *p*-nitrobenzaldehyde condense, when their methanolic solution is irradiated, to give a product which can be recrystallized from isopropyl alcohol and melts at 171°. It contains the amino-ester and the aldehyde in the ratio 1:2. *Anal.* Calcd. for $C_{19}H_{19}O_7N_3$: C,56.8; H,4.7; N,10.4; OC_2H_5, 11.2; N-CH_3, 7.2. Found: C,56.5; H,4.7; N,10.8; OC_2H_5,10.9; N-CH_3,6.6.



I

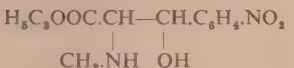


II

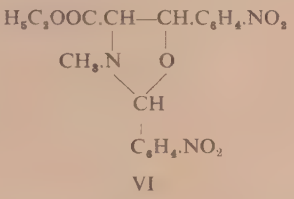


III

IV



V



VI

It is tentatively assumed that the primary product (V) condenses as a secondary β-hydroxy-amine[6] with a second molecule of the aldehyde, giving (VI). The infrared spectrum proves that no hydroxyl group is present in the molecule.

ERNST D. BERGMANN
HILLEL BENDAS
Scientific Department,
Israeli Ministry of Defence,
Jerusalem and Tel-Aviv.

REFERENCES

1. BERGMANN, E., GENAS and BENDAS, 1950, *Compt. Rend.*, **231**, 361.
2. BERGMANN, E., BENDAS and TAUB, 1951, *J. Chem. Soc.* 2673.
3. ELPHIMOFF-FELKIN, FELKIN and WELVART, 1952, *Compt. Rend.*, **234**, 1789.
4. KROEHNKE and co-workers, 1940, *Ber. Dtsch. Chem. Ges.*, **73**, 310; 1951, **84**, 388, 399, 411, 941, 948, 956; 1952, **85**, 368.
5. WOOD and DU VIGNEAUD, 1940, *J. Biol. Chem.*, **134**, 444.
6. BERGMANN, E., ZIMKIN and PINCHAS, 1952, *Rec. Trav. chim. Pays-Bas*, **71**, 237.

Received May 1952

THE IMMUNIZING POTENCY OF LIVING *BRUCELLA ABORTUS* VACCINES TESTED IN LETHAL INFECTIONS OF WHITE MICE PRODUCED WITH THE AID OF THE MUCIN TECHNIQUE

Lethal infections of mice with *Brucella abortus* were produced by intra-abdominal injections of fourfold concentrated 48 hour broth cultures along with equal parts of a 10 per cent mucin suspension. An almost 100% mortality occurred when 0.5 ml of the described bacteria-mucin mixture per 10 g of body weight was injected. The injections of sublethal quantities produced chronique infections where *Brucella* was isolated from the organs more than one month after the onset of the infection[1]. With the aid of this

TABLE I

Results of immunization experiments with four different strains

Immunization: Three subcutaneous injections of 0.5 ml at seven-day intervals

Challenge strain: Swiss strain No. 19

B. abortus-strain employed	Dilutions of vaccine injected	Immunized animals			Cumulative numbers			Percentage of surviving animals
		Died	Survived	Total	Died	Survived	Total	
America 19	Undiluted	1	4	5	1	24	25	96.0
	Diluted 1:10	0	4	4	1	20	21	95 2
	„ $1:10^2$	1	4	5	2	16	18	88.9
	„ $1:10^3$	2	7	9	4	12	16	75.0
	„ $1:10^4$	4	1	5	8	5	13	38.4
	„ $1:10^5$	2	3	5	10	4	14	28.6
	„ $1:10^6$	3	1	4	13	1	14	7.0
	„ $1:10^7$	5	0	5	18	0	18	0
Swiss 19	Undiluted	2	3	5	2	28	30	93.3
	Diluted 1:10	0	4	4	2	25	27	92.6
	„ $1:10^2$	0	5	5	2	21	23	91.3
	„ $1:10^3$	1	9	10	3	16	19	84.2
	„ $1:10^4$	4	0	4	7	7	14	50.0
	„ $1:10^5$	2	3	5	9	7	16	43.8
	„ $1:10^6$	2	2	4	11	4	15	26.7
	„ $1:10^7$	3	2	5	14	2	16	12.5
London	Undiluted	0	5	5	0	29	29	100.0
	Diluted 1:10	0	5	5	0	24	24	100.0
	„ $1:10^2$	0	5	5	0	19	19	100.0
	„ $1:10^3$	3	7	10	3	14	17	82.4
	„ $1:10^4$	2	2	4	5	7	12	58.3
	„ $1:10^5$	1	4	5	6	5	11	45.4
	„ $1:10^6$	5	0	5	11	1	12	8.3
	„ $1:10^7$	3	1	4	14	1	15	7.1
Local strain	Undiluted	2	3	5	2	18	20	90.0
	Diluted 1:10	1	4	5	3	15	18	83.3
	„ $1:10^2$	2	1	3	5	11	16	68.7
	„ $1:10^3$	5	5	10	10	10	20	50.0
	„ $1:10^4$	4	1	5	14	5	19	26.3
	„ $1:10^5$	3	1	4	17	4	21	19.0
	„ $1:10^6$	4	1	5	21	3	24	12.5
	„ $1:10^7$	3	2	5	24	2	26	7.9

technique we observed the protective effect of serums from diseased as well as immunized cattle[2], and we studied the therapeutic effects of antibiotics adn drugs[3].

An attempt was made to protect mice from this type of lethal infection by vaccination with sublethal doses of living *Brucella abortus* strains. Four different strains were employed: the American strain No. 19; the Swiss strain No. 19 which constitutes a variant of the former; a virulent *B. abortus* from the National Type Collection in London; and a local strain, which was subcultured many years on agar slants in our laboratory. After several subcultures on broth, 48 hour broth cultures were employed which showed a uniform turbidity. On the day of the vaccination, serial dilutions starting from 1:10 up to $1:10^7$ were prepared. Groups of at least five mice received varying dilutions prepared from the different strains. Each animal received three subcutaneous inoculations at seven day intervals of 0.5 ml of vaccine, totalling

1.5 ml. The mice tolerated these injections well, and among 180 animals only 11 deaths were observed during the immunization period.

Twenty-six days after the last injection the animals weighed on the average 20 g. They received 1.0 ml of the bacteria-mucin mixture intra-abdominally, as did also 40 non-vaccinated animals. While 90% of the non-vaccinated controls died, the vaccinated mice showed a definite protective effect of the preceding vaccination which was closely correlated with the quantity of the injected living vaccine.

The results of these experiments are summarized in Table I.

The different strains employed for vaccination showed different immunizing potency. The ED_{50} obtained according to the method of Reed-Muench were as follows:

American strain No. 19
3 x 0.5 ml of the dilution 1:7,000
Swiss strain No. 19
3 x 0.5 ml of the dilution 1:10,000
London, Nat. Type Coll.
3 x 0.5 ml of the dilution 1:60,000
Local strain
3 x 0.5 ml of the dilution 1:1,000

Since we determined that the undiluted broth cultures contained 200 millions of living bacteria per ml, that means that the respective quantities of living bacteria administered at each injection were 14,000, 10,000, 1,600 and 100,000.

The surviving animals were killed and their organs cultured. The *Brucella* disappeared after a relatively short time from the organs and the percentage of the infected animals decreased rapidly, as shown by the following figures:

Time after the onset of the infection (in weeks)	Total number of animals dissected	All organs found sterile	Percentage of animals found sterile
1	16	2	12.5
2	15	9	60.0
3	15	11	73.3
4	14	12	85.7
5	4	4	100.0

A. L. Olitzki
R. Kushnir
Department of Bacteriology,
Hebrew University—
Hadassah Medical School,
Jerusalem.

REFERENCES

1. Dishon, T. and Olitzki, L., 1949, *Proc. Soc. Exp. Biol. and Med.*, 71, 693.
2. Olitzki, L. and Oren, R., 1950, *Proc. Soc Exp. Biol. and Med.*, 73, 617.
3. Olitzki, L., Farkas, H., Olitzki, Z. and Friedman, D., 1950, "Therapy of experimental lethal *Brucella* infections of white mice", Preliminary Report, *5th International Congress of Microbiology*, Rio de Janeiro, Brazil, 88-89.

Received July 1952

INFECTION OF SUCKLING MICE WITH A NUTTALLIA OF *MERIONES TRISTRAMI*

The gerbil *Meriones tristrami* is frequently infected with a non-pathogenic Nuttallia. After splenectomy the parasites multiply till 90% or more of the red cells are infected, but the infection is seldom fatal. Repeated passage through splenectomised animals enhances the pathogenicity of the Nuttallia for *M. tristrami* and after a few passages a mortality of about 55% is attained (19 out of 34 animals).

The above Nuttallia is non-infective for rats, cotton rats, hamsters, field mice, *Microtus guentheri*, and very rarely (1 in 50) produces a slight transient infection in adult mice which lasts for a day or so and does not relapse after subsequent splenectomy.

It is interesting to note that the parasite multiplies in suckling mice during the first 24 hours after an injection of 0.2 cc infected blood; (73 out of 73 animals became infected). After 24 hours up to 2 % of the red cells are infected and there are numerous dividing forms. Subsequently the infection diminishes progressively although parasites are found in blood smears up to nine days after inoculation. Even when few, the parasites in suckling mice are viable for inoculation into splenectomised clean laboratory-bred *Meriones tristrami* constantly produces a heavy infection.

Continued passages from suckling mice to suckling mice have so far not proved successful. In the first passage 12 out of 29 and in the second passage only one out of five animals showed a slight infection.

In suckling mice the parasites are found only in mature red cells and we have never seen parasitised normoblasts or young basophils (in contrast to *Plasmodium berghei* which frequently infest normoblasts and generally shows a preference for young erythrocytes.

This work was carried out for the Research Council of Israel.

S. Adler
B. Feldman-Muhsam
Department of Parasitology,
Hebrew University—
Hadassah Medical School,
Jerusalem

Received August 1952

TRANSMISSION OF A NUTTALLIA OF THE GERBIL *MERIONES TRISTRAMI* BY *RHIPICEPHALUS SANGUINEUS* LAT S. STR.

Adler and Feldman-Muhsam[1] proved that the Nuttallia of *Meriones tristrami* prevalent in Israel can be transmitted in the laboratory by *Rhipicephalus sanguineus* Lat s. l. Feldman-Muhsam[2] found that *R. sanguineus* Lat consists of two species, *R. sanguineus* s. str. and *R.*

secundus n.sp. The transmission experiments previously recorded[1] refer to *R. secundus* Feldman-Muhsam. We have recently found that *R. sanguineus* s.str. also transmits the above mentioned Nuttallia. The following ezperiments were carried out with laboratory bred *R. sanguineus:*

9.5.52 — Larvae hatched.
19.5.52 — Larvae placed on an infected *M. tristrami.*

After the gorged larvae had detached themselves (after about three days) they were placed in an incubator at 26°C, relative humidity c. 80%

After 8 days 50% of the larvae moulted and became nymphs.

8.6.52 — The nymphs were placed on a clean laboratory bred *M. tristrami*
20.6.52 — Blood films of the *M. tristrami* showed Nuttallia.

The above work was carried out on behalf of the Research Council of Israel.

S. Adler
B. Feldman-Muhsam
Department of Parasitology, Hebrew University—Hadassah Medical School, Jerusalem.

REFERENCES

1. Adler, S. and Feldman-Muhsam, B., 1952, *Nature*, 169, 552.
2. Feldman-Muhsam, B., 1952, *This Journal*, 2, 187.

Received August 1952

INHIBITION OF DECIDUOMA FORMATION BY ANTIHISTAMINIC AGENTS

An earlier communication[1] reported the effectiveness of diphenhydramine (benadryl) in suppressing the development of the artificial decidual cell reaction (deciduoma)[2] of the uterus of the pseudopregnant rat. It has also been shown that a histamine antagonist of an indirect type, namely one which blocks the responding tissue — ephedrine hydrochloride — produces an inhibition of the deciduoma development[3]. This is a note to report that other direct antihistaminic agents act as does benadryl.

Nine adult female rats (140—170 gm) were made pseudopregnant by electrical stimulation of the cervix[4] during oestrus stage of the cycle. On the 4th day of pseudopregnancy the animals were operated under anesthesia and both horns of the uterus irritated mechanically by transverse clamping with a haemostat forceps. One horn received in addition, an intralumen implant of 0.7 mg phenazoline (anhistine) at the site of clamping. In no case did a deciduome develop at the experimental site, though in all control horns large decidual growth were seen at autopsy on the 4th post operative day.

A second series of 10 pseudopregnant rats (175—220 gm) in which bilateral uterine irritation was caused by injection of 0.05 mg histamine dihydrochloride in 0.05 ml saline, unilateral injection of 0.07 mg of promethazine (phenergan) in 0.05 ml showed decidual growth suppression by the antihistamine.

These results are consistent with those elicited by diphenhydramine.

M. C. Shelesnyak
Dept. of Expt. Biology, Weizmann Institute of Science, Rehovot.

REFERENCES

1. Shelesnyak, M. C., 1952, *Bull. Res. Counc. of Israel*, 2, 74.
2. Loeb, L., 1907, *Centrblt. f. allg. Path. u. path. Anat.*, 18, 563.
3. Shelesnyak, M. C., 1952, *Amer. J. Physiol.*, (in press).
4. Shelesnyak, M. C., 1933, *Anat. Record.*, 56, 211.

Received July 1952

THE ACTION OF COLCHICINE ON COLCHICINE-RESISTANT STRAINS OF *TRICHOMONAS VAGINALIS* DONNE

A strain of *T. vaginalis* which has been maintained in the laboratory since 1944 was made resistant to various concentrations of colchicine by gradually increasing the concentration of drug in the culture medium.

The following observations were made on four substrains made resistant respectively to 1 in 3,000, 1 in 2,000, 1 in 1,600 and 1 in 1,300 colchicine. The majority of our experiments were carried out mainly with the first and third substrains but identical results were obtained with the other two.

After 9 months growth on colchicine-free medium the substrains produced normal cultures on 1 in 3,000 and 1 in 1,600 colchicine. During this period approximately 540 nuclear divisions had taken place. After 10 months on colchicine-free medium (i.e. after approximately 60 more nuclear divisions) they were again grown on 1 in 3,000 and 1 in 1,600 colchicine. Again a rich culture was obtained, but in addition to a varying number of normal flagellates there were large bizarre multinucleated amoeboid forms up to 70 μ in size (Plate 1, Figures 1, 2, 3, 4, 5, 7, 9 and 10) and large multinucleated spherical masses up to 50 μ or more in diameter (Figure 6). In the large amoeboid forms the pseudopodia either show no perceptible motion or move very slowly; in one case a pseudopodium was retracted at the rate of 10 μ in half an hour. There was no perceptible streaming in the cytoplasm of these abnormal forms nor was there any sign of Brownian movement. These large organisms contained from a few to as many as 50 nuclei and a varying number of blepharoplasts. Flagella were absent in most abnormal forms, but some large protoplasmic masses contained several sets of active flagella.

The nuclei were often hypertrophied (up to 14 μ); the karyoplasm had a faint pink yellowish tinge and in contrast to the cytoplasm showed very active Brownian movement. The blepharoplasts also appeared somewhat hypertrophied and contained a fluid similar to that of the nuclei.

In stained specimens (with Heidenhain) some of the nuclei showed polyploidy (up to 15 chromosomes). In large aflagellar organisms an axostyle and its associated granules were often seen. These granules which take chromatin stains are solid greyish masses quite different in their *in vivo* appearance from the contents of nuclei and blepharoplasts.

The large amoeboid forms ingest starch granules often in large number (Figure 5). The process of ingestion appears to be as follows: the starch granules which happen to come in contact with the organisms adhere to their surface and are slowly dragged into the cytoplasm. No active ingestion of starch granules by pseudopodia was observed.

Continued observation of the large abnormal forms indicated that the process of division was as follows: A small mass of protoplasm about 10 μ in diameter buds off from the main mass to which it remains connected by a bridge of protoplasm. This bridge becomes stretched till it may attain a length of 150 μ and a thickness of not more than 1 μ. Occasionally both the protoplasmic bridge and the attached protoplasmic mass are retracted and reincorporated into the parent mass of protoplasm. We have observed a protoplasmic bridge 150 μ long and an attached globular mass of protoplasm retracted and reincorporated into the main mass in about 2 minutes. The rate of retraction varies and in another instance we observed a bridge 40 μ long and 3 μ which retracted and reincorporated in about 5 minutes. The connecting protoplasmic bridge breaks not in the middle but near the smaller mass, and its remains are retracted into the corresponding protoplasmic masses. As a result of this unequal division, the culture after 6 days contains relatively large organisms up to 70 μ in their biggest diameter and small round aflagellar organisms about 12 μ in diameter.

In some instances the protoplasmic masses while still united by a bridge of protoplasm proceed to divide and this process is repeated till an irregular chain of up to 800 μ in length consisting of organisms of various size is formed. Figures 9 and 10 show a part of a bridge between abnormal forms. Protoplasmic swellings may appear at various points of the bridge (Figures 9 and 10). These protoplasmic swellings, if invaded by nuclei, develop into larger organisms. After six days culture, normal organisms may be rare, and at this stage subculture on colchicine-free medium gives either a negative result or a normal culture. If flagellates from the above normal culture are sown on medium containing colchicine, abnormal forms are again produced. The behaviour of the above abnormal forms, i.e. the absence of Brownian movement in the cytoplasm, the retraction of long protoplasmic processes and the persistance of the protoplasmic bridges between the parent and daughter cells appears to be the result of an increased viscosity which inhibits the division of protoplasm. The formation of the above described abnormal forms is apparently due to the failure of protoplasm to divide after the division of blepharoplasts and nuclei has been completed. It is interesting to note that in cultures 6 days old and over, slow extrusion of nuclei and blepharoplasts from the monster organisms occurs.

The addition of colchicine to the medium immediately or 24 hours after sowing the above resistant substrain invariably produces the above abnormal forms. If the colchicine is added three days after sowing, i.e. when the population of flagellates approaches its maximum density, the culture remains normal. This indicates that only flagellates which are dividing are sensitive to the colchicine, whereas non-dividing forms are not affected.

Another point of interest is that the concentration of colchicine capable of inducing the appearance of these abnormal forms is much smaller than the concentration to which the substrain is resistant, e.g. in a substrain resistant to 1 in 1,600 colchicine, large abnormal forms were produced by the addition of 1 in 11,000, a concentration in which few flagellates of the original isolated strain survived but showed no morphological abnormalities.

Two factors are necessary for the production of the large above described amoeboid and spherical monsters.

1. The production of a resistant substrain.
2. A sufficient period of growth on colchicine-free medium (corresponding approximately to about 500 divisions. Our substrain divides once in 10 to 12 hours under laboratory conditions).

If a resistant substrain is kept continuously in a medium containing colchicine, the above described response does not occur, e.g. a substrain resistant to 1 in 600 colchicine maintained continuously for 10 months in 1 in 600 colchicine produces flagellates normal in size and shape.

We wish to thank Dr. Anna Weizmann of of the Weizmann Institute of Science, for preparation of pure colchicine from *Colchicum hierosolamitanum* Feinbr.

Full details will be published elsewhere.

S. Adler
E. Meerovitch
Dept. of Parasitology,
Hebrew University–Hadassah Medical School,
Jerusalem.

Received September 1952

9th MEETING OF THE MICROBIOLOGICAL SOCIETY OF ISRAEL
MARCH 10—12, 1952, JERUSALEM

Summaries of papers presented in the Virus Section

Received April 1952

THE EFFECT OF SERIAL PASSAGES IN EMBRYONATED EGGS ON THE PATHOGENICITY OF RABIES VIRUS

Out of six strains of street virus and four fixed rabies viruses, cultivated and passed serially in embryonated eggs, one strain only (strain Kelev) underwent marked modification in virulence. Strain "Kelev" was isolated from a rabid dog, positive for Negri bodies. Specific rabies immune serum (Lederle) neutralized the virus. After one intra-cerebral passage in mice, the M.L.D. titre of the virus for mice on intracerebral inoculation was $0.03cc \times 10^{-5.1}$ Rabbits inoculated with 0.5cc of a 20 % emulsion of the same material, into the masseter muscles, died after 12—18 days.

Brain emulsion from the fourth serial intracerebral passage in mice was inoculated into embryonated eggs according to the method described by Koprowsky and Cox[1].

Negri bodies were found in the brain of mice inoculated with 20% embryo emulsion, passages 1, 5, 6, 9 and 14 of strain Kelev in embryonated eggs. Negri bodies were not detected in brain of mice inoculated with embryo emulsion of passage 21 and further egg passages. As from passage 26 in embryonated eggs the virulence of the virus for mice, rabbits and hamsters was considerably modified. This report will deal only with the results obtained in mice. 113 mice (22—57 days old) were inoculated intra-cerebrally with 0.03cc of a 20% embryo emulsion from the 1st to the 26th passage—all died. Out of 307 mice inoculated as above with embryo emulsion from passages 26—44: 41 (13.3%) did not show any clinical symptom; 189 (62%) showed clinical symptoms of encephalitis and survived; 77 (22%) sickened and died. 37 out of the 41 mice of the first group and 129 out of 189 mice of the second group were tested for immunity. A part of the above mice received an intracerebral challenge dose of 50,000 M.L.D. of the Standard Challenge Rabies Virus (National Institute of Health, U.S.A.) and the rest 100,000 M.L.D. of Pittman-Moor, U.S.A. strain of rabies virus. 33 mice of the first group and 126 of the second group remained unaffected.

In another experiment the virulence of strain Kelev at its 48th passage in embryonated eggs, was tested in mice of different ages. The mice were inoculated with 0.03cc of a 20% embryo emulsion intra-cerebrally. The results obtained are summarized in Table I.

The mice which remained unaffected following inoculation with material from the 48th passage were divided into 3 equal groups and were tested for immunity as follows. Group 1 received 100 M.L.D., group 2 1000 M L.D. and group 3 10,000 M.L.D. of Pittman-Moor strain of rabies virus intracerebrally. All of the tested mice survived.

A. KOMAROV
K. HORNSTEIN
Virus Diseases Laboratory, Haifa.

REFERENCE

1. KOPROWSKY, H., and COX, H. R., 1948, *J. of Immunology*, **60**, 533.

TABLE I

Pathogenicity of 48th egg passage for mice

No. of mice inoculated	Age of mice in days	Results		
		Unaffected	Affected and survived	Affected and died
45	57	17 (37.7%)	27 (60%)	1 (2.2%)
44	47	17 (38.6%)	26 (59%)	1 (2.2%)
45	29	12 (26.6%)	30 (66.6%)	3 (6.6%)
51	21	9 (17.6%)	22 (45%)	20 (39.2%)

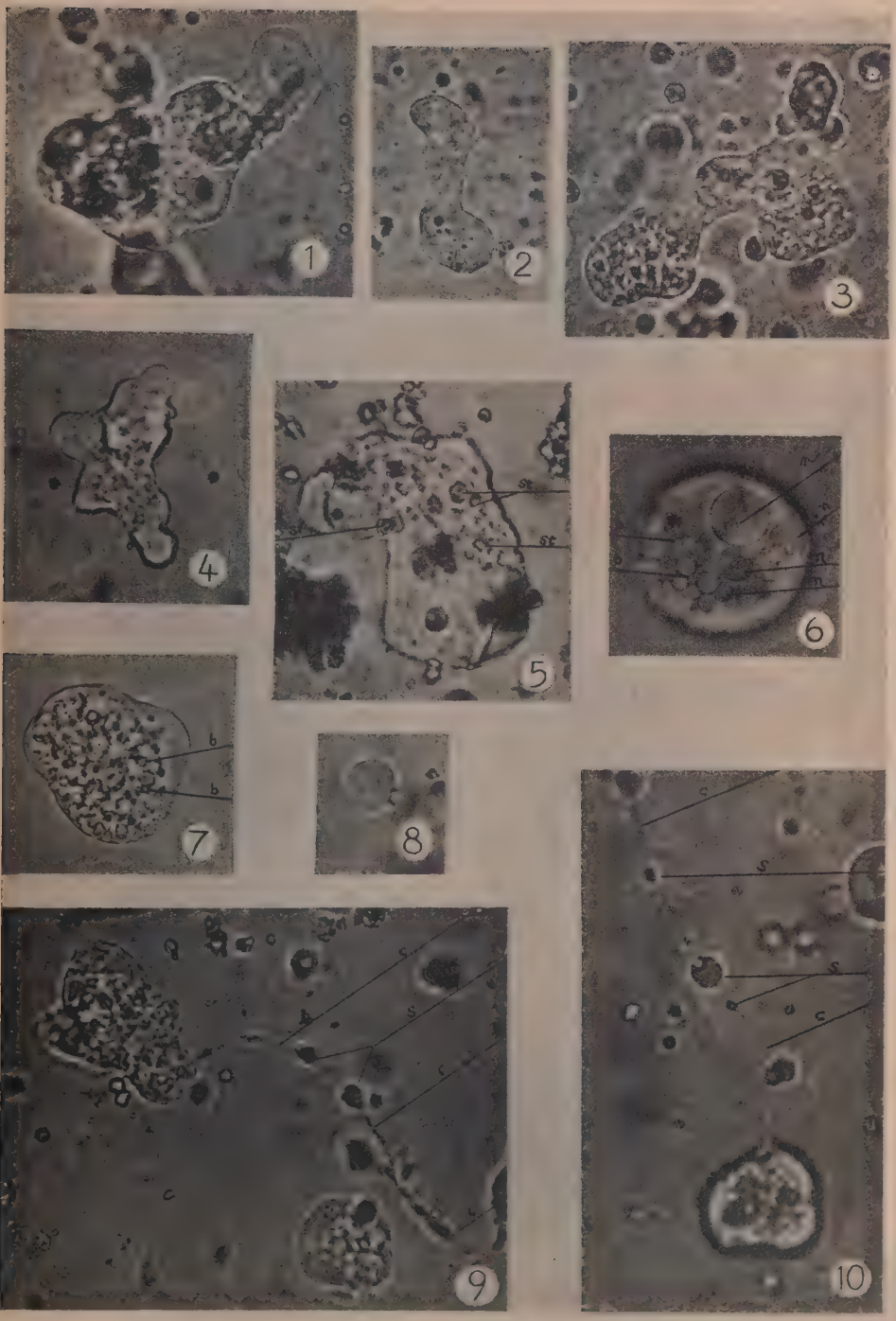


Plate I: *Trichomonas vaginalis* × 550 (All photographs made from living specimens.)

Figures 1,2,3,4,5,7 Large amoeboid forms of *Trichomonas vaginalis*. Figure 6 Large spherical form of *T. vaginalis* with numerous nuclei and blepharoplasts. Several of the nuclei are markedly hypertrophied. Figure 8 Flagellate *T vaginalis* from normal culture Flagella not seen in photograph, Figure 9 and 10 Abnormal *T. vaginalis* continuous with long connecting protoplasmic bridge only part of which is seen in the photograph.

n nucleus, *b* blepharoplasts appear in photograph as small round white areas, *c* long protoplasmic bridges between abnormal organisms, *s* swellings on course of protoplasmic bridge, *st* starch granules.

(See page 202—205)

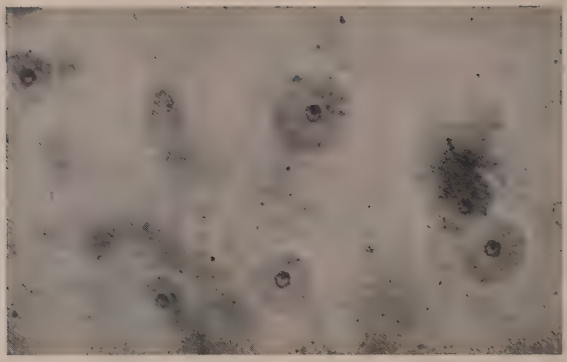


Figure 1
Colonies of Haifa strain of Pleuropneumonia-like organisms, (300 X), unstained.

Figure 2
Colony of Haifa strain (3000 X), stained

These photographs an published with the kind permission of Dr. Klineberger-Nobel, Lister Institute, London.

(See p. 207)

PLEUROPNEUMONIA-LIKE ORGANISMS IN PELVIC ABSCESS

Pleuropneumonia-like organisms were isolated by Klieneberger for the first time in 1935 from cultures of *Streptobacillus moniliformis* and since 1937 by Dienes and other authors in normal and pathological conditions of the human genito-urinary tract. Dienes and co-workers isolated pleuropneumonia-like organisms together with other bacteria from pelvic abscesses in two cases. The etiological significance of such findings has been much discussed.

A case of pelvic abcess is presented from which growth suggestive of pleuropneumonia-like organisms was obtained in pure culture. This suggestion was confirmed by Dr. Klieneberger-Nobel, London, to whom the culture was sent. (See Plate page 206).

As the patient received intensive though non-effective penicillin treatment before the abscess was opened, it cannot be stated with certainty that the infection was caused only by pleuropneumonia-like organisms which are known to be penicillin resistant. On the other hand, it might be suggested that the penicillin treatment induced bacteria possibly responsible for the infection to undergo variation, as described by Dienes, and to produce organisms which have all the characteristics of the pleuropneumonia group. No conclusive evidence, therefore, is possible concerning the pathogenicity of the pleuropneumonia-like organisms in our case.

W. Hirsch
Central Laboratory of Kupat Holim, Haifa.

A SURVEY OF ANTIBODIES AGAINST THE LANSING STRAIN OF POLIOMYELITIS IN THE ISRAEL POPULATION

The occurrence of neutralizing antibodies against the mouse-adapted strain of poliomyelitis was determined in different age groups of the following sectors of the population of Israel: (a) inhabitants of Jerusalem, (b) members of communal settlements in Galilee, (c) new immigrants from Yemen. Blood was collected from 10 individuals of each age group (0-1, 1-2 years, etc.) and of each sector. A total of 393 sera were examined. It was found that the percentage of Lansing positive sera rises from 13% in the first and 35% in the second and third years of age to above 50% in the age group of 4-5 years. In the higher age groups, figures approach 100%.

Comparison of our results with similar examinations carried out in other countries shows that antibodies appear in Israel at a later age than in a group of Egyptian children examined by Paul *et al.*[1] but earlier and reaching a higher percentage than is frequently found in the Anglo-Saxon countries. Taking Lansing antibodies as an indication of acquired immunity, these differences may serve as one possible explanation for the fact that the poliomyelitis epidemic in Israel in 1950-51 did not spread to neighbouring countries such as Egypt. Immunity seems to be acquired there at an earlier age. It is significant that those age groups which showed a low percentage of Lansing antibodies in our survey had the highest case rates during the poliomyelitis epidemic despite the fact that strains of the Brunhilde and not of the Lansing type were isolated from local material sent to the Yale Poliomyelitis Study Group. It is apparent that strains of both the Lansing and the Brunhilde type are widespread in Israel and that contact with both is made at about the same time of life. Antibodies against the Lansing strain may, therefore, also be used as indicators for contact of the population with other strains of poliomyelitis.

H. Bernkopf
Virus Laboratory, Hebrew University—Hadassah Medical School, Jerusalem.

S. Levine
Department of Hygiene, Israel Ministry of Health.

REFERENCE

1. Paul J. R. *Second International Poliomyelitis Conference*, Kopenhagen, 1951.

SUSCEPTIBILITY OF SUCKLING MICE TO INFECTION WITH *VACCINIA* AND *VARIOLA* VIRUSES

Three to four-week-old mice respond in an irregular manner to infection with the viruses of *Vaccinia* and *Variola*. It was decided to examine the susceptibility of suckling mice to these viruses.

Four strains of *Vaccinia* and two strains of *Variola*, obtained from different sources, were tested. For inoculation of the animals, suspensions in broth were prepared from chorioallantoic membranes showing confluent or rich growth of the virus.

The animals were inoculated intra-cerebrally, intra-peritoneally or intra-nasally. The presence and titer of the virus in the inoculated animals was determined by titration of suspensions of the organs on the chorioallantoic membrane.

Two to four-day-old mice inoculated with a 10% suspension intra-cerebrally show the first clinical signs of the disease on the third day after inoculation and as a rule die on the fourth day. The LD_{50} after i.c. inoculation with

Vaccinia Virus is a 10^{-5} dilution of the egg membrane suspension and a 10^{-4} dilution after inoculation with *Variola* Virus. The LD_{50} after intra-peritoneal inoculation with these viruses was one log. lower. The susceptibility was lowest and the incubation period longest after intra-nasal inoculation. (LD_{50} 10^{-3} for *Vaccinia* and 10^{-2} for *Variola*, with 5 to 7 days incubation.) In two to four-day-old mice, the viruses produce a generalized infection and can be recovered from all the organs, independent of the route of inoculation. When the incubation is longer than 3 to 4 days (such as after intra-nasal inoculation or after inoculation of higher dilutions of the virus given intra-cerebrally or intra-peritoneally), characteristic poxes appeared on the skin in a certain proportion of the animals.

In ten-day-old animals both viruses produced disease and death after i.c. inoculation and could be recovered from the brain, lung and kidney but not from the liver, spleen and other organs: whereas after intra-nasal inoculation, no clinical symptoms were observed. After i.p. inoculation, only *Vaccinia* virus produced disease and death.

In fifteen-day-old mice, disease and death occurred only after i.c. inoculation, and the virus could be recovered from the brain alone.

In three to four-week-old mice, disease and death occurred in a proportion of the animals after intra-cerebral inoculation with onetrains of *Vaccinia* only.

Sections from organs of infected animals showed characteristic changes such as interstitial pneumonia myositis, encephalitis, and nephritis.

Suckling mice may prove useful in certain experimental work on *Variola* and *Vaccinia* virus, such as studies on the pathogenesis of the disease or the effect of chemotherapeutics.

E. Rabinovitz
H. Bernkopf
Virus Laboratory,
Hebrew University—
Hadassah Medical School,
Jerusalem.

THE OCCURRENCE OF *COXSACKIE* VIRUSES IN ISRAEL

Coxsackie viruses were first isolated from patients during a poliomyelitis epidemic. They have been recovered from flies and sewages in areas where poliomyelitis was prevalent. Both poliomyelitis and *Coxsackie* viruses have been isolated from the same patients, who showed a dual antibody response. They have also been isolated from other illnesses such as "summer grippe", three day fever, influenza-like fevers and fevers of unknown origin. The actual role of the *Coxsackie* viruses in all these diseases is not clear as yet. In two illnesses, however, herpangina and pleurodynia, evidence has been produced to show that *Coxsackie* viruses are the etiologic agents.

The study on the occurrence of the *Coxsackie* viruses in Israel was planned as follows: Isolation of *Coxsackie* viruses (1) from poliomyelitis cases, both paralytic and non-paralytic; (2) from patients with a variety of illnesses other than poliomyelitis; (3) from healthy individuals. Parallel with the latter an immunological study to determine the presence of antibodies to the *Coxsackie* viruses in sera collected from normal individuals of various age groups was carried out.

The present preliminary report presents findings covering the first two parts of the study. The isolation of two strains of *Coxsackie* viruses from outbreaks diagnosed as pleurodynia or Bornholm disease is included.

Fecal specimens from 111 poliomyelitis cases have been studied. Ten strains of *Coxsackie* viruses were isolated, (9.1% isolations). Distribution of the viruses is shown in Table I.

TABLE I

Type of Cases	Number of cases studied	Number of *Coxsakie* strains isolated	Per cent Isolations
Paralytic	65	5	7.7
Non-paralytic	46	5	10.8
Total	111	10	9.1

Fecal specimens from 80 patients with a variety of illnesses other than poliomyelitis were studied. Since most poliomyelitis cases occur among children from the age of several months to 6 years, the same age group has been used for this study. Six strains of *Coxsackie* viruses were isolated (7.5% isolation). Comparisons with isolations from poliomyelitis cases are shown in Table II.

TABLE II

Type of Cases	Number of cases studied	Number of *Coxsackie* strains isolated	Per cent Isolations
Poliomyelitis	111	10	9.1
Other diseases	80	6	7.5

A study of the types of diseases from which *Coxsackie* viruses were recovered revealed a high percentage of virus isolations from infants whose condition was described as "dystrophia". From 19 cases studied, five (or 26.3%) were found to excrete viruses in their stools. Only one strain was recovered from the stools of the other 61 patients (1.6%).

A strain of *Coxsackie* virus was isolated from

an outbreak diagnosed as pleurodynia or Bornholm disease which occurred in Naot Mordechai in September, 1950. Another strain was isolated during a similar outbreak in Kibbutz Maapil in March, 1951. Both strains belong to group B, and appear to be of the same type, on the basis of cross infection tests, and to have other properties in common. They are considered to be the etiologic agents of the outbreaks.

The complete study of the occurrence of *Coxsackie* viruses in Israel, including classification of the strains isolated, will be presented at a later date.

S. Levine
Department of Hygiene,
Israel Ministry of Health

H. Bernkopf
Virus Laboratory,
Hebrew University—
Hadassah Medical School,
Jerusalem.

ISOLATION OF A VIRUS CLOSELY RELATED TO WEST NILE VIRUS FROM THE BLOOD OF A SICK CHILD DURING AN EPIDEMIC IN MA'AYAN TSEVI.

During the months from July to September 1951, a febrile disease in epidemic form occurred in the communal settlement Ma'ayan Tsevi which is situated in the Coastal Plain of Israel near Haifa. Both children and adults were attacked. Fever, symptoms pointing to meningeal involvement and a rash were present in many cases among the children; in adults severe headache and general malaise were the main complaints. The temperature remained high for a few days only; recovery was complete, more rapid in the children than in the adults. From the blood of a fourteen year old sick child a virus was isolated which was found pathogenic for mice, hamsters, field mice and the developing chick embryo. It was filterable through Seitz filters. Bacteriological examinations of infective material were always negative. A number of passages were carried out in both mice and eggs. In mice the virus is present in highest concentration in the brain; it is also found in the blood and the other organs. On histological examination constant changes were present in the brain only, in which destruction of neurons and inflammatory changes were always found. No inclusion bodies could be demonstrated. Mice could be infected by various routes. In the egg the virus produced focal lesions on the membrane and ultimate death of the embryo. The virus was neutralized by antiserum against West Nile virus and, to a lesser degree, by antisera against Japanese B and St. Louis encephalitis. Other antisera were without effect. Immune mice are rseistant to intracerebral infection with at least 10^4 lethal doses of a strain of West Nile virus obtained from Dr. J. L. Melnick (Yale University). The virus is obviously closely related to or identical with West Nile virus. Neutralizing and complement fixing antibodies against the isolated strain developed during the disease in a number of patients. Further work to elucidate the etiologic significance and epidemiology of the virus is in progress.

H. Bernkopf
Virus Laboratory,
Hebrew University—
Hadassah Medical School,
Jerusalem.

S. Levine
Department of Hygiene,
Israel Ministry of Health

ISOLATION OF NEUROTROPIC VIRUSES

The Epidemiological Laboratory of the Ministry of Health is used as a reference diagnostic laboratory for the identification of virus diseases. We wish to give herewith a summary of several isolations of neurotropic viruses in this country. Because of the similarity of *Coxsackie* viruses to neurotropic ones, we have included the former in this report. In relation to the epidemiological research on poliomyelitis, a virus has been isolated from a girl aged 2 years old who showed symptoms of facial paresis, right deltoid paralysis and a C.S.F. with 180 cells, Pandy —, and protein 60 mg %. This virus, when injected intra-cerebrally into *Macacus rhesus*, caused an increase of temperature to about 40^0 after 3 days, and paralysis of the dorsal muscles on the 6th day. Histology of the spinal cord showed a a typical picture of poliomyelitis. From the spine substance, we could transfer the disease to a second and from this to a third one, with the resulting paralysis and typical histological findings of poliomyelitis.

This strain was identified as Brunhilde, i.e. belonging to the same group of viruses formerly isolated in Israel by Prof. Paul of Yale University. During the winter of 1952, the year third of the polio epidemic in Israel, there was a relative rise in the number of cases without any change in the epidemiological pattern, especially in the age distribution of the cases.

It was thought to be interesting to find out if the same virus strains prevail at the end of the third year of the epidemic. For this reason a virus was isolated in a monkey from an epidemic outbreak in a kibbutz. This settlement contained 55 children of which 7 came down with paralytic poliomyelitis (2 died), and 45 showed a rise in temperature and a general malaise. The identification of the virus is not yet completed. All the attempts, on over 100

cases, to isolate a Lansing strain from this epidemic were negative.

From paralytic and non-paralytic poliomyelitis cases, from children with other diseases and from children without clinical symptoms, attempt was made to isolate the *Coxsackie* viruses. Successful isolations were made from paralytic and non-paralytic polio cases and from cases of pleurodynia. 8 strains swere identified by Prof. Melnik at Yale University. Two of these strains were identical with Texas 14, and one with Eastern 10, whilst the other 5 belonged to a new strain, not previously known, now called Israel 7.

From the brain of a 3 year old girl dead of encephalitis, a virus was isolated. By its behaviour on the chorio-allantonic membrane of embryonated eggs, in white mice, and in rabbits' corneas, and according to the histological findings it was found to be identical with the herpes virus. Anti-virus rabbit serum gave neutralization with herpes virus.

E. Olejnik
R. Schmutzka
Y. Ginsberg

The Epidemilogical Laboratory
Israel Ministry of Health

INFECTIOUS ADENITIS TRANSMITTED BY *CULEX MOLESTUS*

Between July 1950 and August 1951 there were outbreaks of an epidemic in army and immigrant camps and Kibbutz Mayan Tsevi.

The disease was characterised by a sudden rise of temperature up to 39.5 C followed by a gradual decrease over 1-6 days. Headaches, conjunctival injection, and swelling of the glands in various parts of the body, were recorded. Some of the cases showed a roseoliform rash accompanied by muscular pains and nystagmus. Most of the cases had an elevated B.S.R. leucopaenia, and a relative lymphocytosis. The disease in general was mild. Except for four cases of meningitis, no complications appeared. Four lumbar punctures showed pandy slightly positive. Histology of the swollen glands showed hyperplasia and a hypertrophic reticulum. Based on the clinical, laboratory, and epidemiological findings, Dengue, Infectious Mononucleosis, German Measles and Rift Valley Fever, were excluded.

In one camp, 60% of the inhabitants became sick. In Mayan Tsevi, the proportion was 140 out of 375. Clinically the disease was identical in various parts of the country. In Mayan Tsevi, most of the children became ill. The incubation period was short: 3-6 days. In some cases it was possible to determine the incubation period by tracing the movements of inhabitants in and out of the camp. In Mayan Tsevi, out of 2 children who entered the Kibbutz in August, one became ill 3 days, and the other, 6 days, later. A woman who spent 2 days in the kibbutz became ill 2 days later. In the fourth class which was not present in the kibbutz until the 15th of August, 2 cases appeared on the 18th of the same month and an additional one on the 20th. In all these cases it was possible to assume a relationship between the spread of the disease and the occurrence of mosquitoes. The evidence for this assumption is as follows:

1. The period, peak, and decline of the disease corresponded with the appearance, maximum multiplication, and disappearance of *Culex molestus*.
2. The first 25 cases in Mayan Tsevi occurred amongst people living in the vicinity of the mosquitoes' breeding places.
3. The strict quarantine which was imposed on a camp where the disease prevailed did not prevent its spread.
4. Camp drivers, and members of the kibbutz working externally, and returning to the camp or the kibbutz for the night, were amongst those infected.
5. People from outside, who were in close contact with the inhabitants only during the day did not catch the disease.
6. Most of the cases in one camp particularly, occurred in the periphery of the camp near orange groves.
7. No further infections occurred in hospitals where cases, and other patients were in close contact.
8. In Mayan Tsevi, a three-week old sick baby was in contact with his mother and grandmother for 17 days and neither of the latter became ill, nor showed neutralizing antibodies in the blood.
9. In spite of the close contact, there was no correlation between the times of sickness of the children, parents, and children's nurses.
10. Women were in much closer contact with children than men, nevertheless most of the cases occurred in men.

From these 3 epidemics occurring in different places, a virus was isolated from patients' blood during the epidemic and in 2 places, from *Culex molestus*.

The virus, which grew on chorio-allantoic membrane of the embryonated egg, caused marked thickening of the membrane, haemhorrhages, appearances of plaques, or diffuse growth, and death of the embryo. Suckling and adult mice and hamsters were infected intra-cerebrally, intra-abdominally, and through intra-nasal instillation. In suckling mice paralysis occurred on the 3rd day, and in adults, between the 5th and 6th days.

The virus can be found in the circulation 4 days after an intra-cerebral inoculation into mice and hamsters. The virus caused a mild reaction, proportionate to its concentration,

when tested on rabbits' skin. A positive 1/124 to 1/228 haemagglutinin titre was obtained. Patients' blood, and sera of immunised rabbits, gave positive neutralising tests in mice, and rabbits' skins. Antigenically the viruses are apparently identical.

Intra-cerebrally infected hamsters were bitten by laboratory bred *Culex molestus*. These hamsters' blood was shown to be infective for other hamsters 2 days after the inoculation. 6, 14, and 20 days later, these mosquitoes bit healthy hamsters, which became ill, and from which the virus could be isolated and transferred to other mice and hamsters.

Thus it was demonstrated that the diseases could be transferred experimentally by mosquitoes, and that the transfer was biological and out a mechanical one.

I wish to express my thanks to Prof. Saul Adler for inspiring the above research and for his advice and interest throughout and to Prof. John E. Gordon for advice and help in the epidemiological investigation.

The investigations in the army camps were carried at together with Drs. Klingenberg, Goldblum, Koch, Tevan, and Raat, and the laboratory experiments with Dr. Goldwasser, Mr. Fendrich, Mr. Davidowitz, Mrs. Smutzka and Miss Ginsberg.

E. Olejnik
The Epidemiological Laboratory, Israel Ministry of Health

THE CAUSATIVE AGENT OF PSITTACOSIS IN ISRAEL

A disease which appeared in a flock of pigeons in Haifa was identified as Psittacosis. Microscopic examination of smears prepared from organs of infected pigeons and stained with Giemsa solution revealed L.C.L. bodies. Mice were found susceptible to both intra-cerebral and intra-peritoneal inoculation of infected material. The causative agent was cultivated in embryonated chicken eggs. The examination of adult pigeons of the flock showed that a considerable number of them were carriers of the disease.

The presence of the disease among pigeons in Israel strengthens the hypothesis advanced by Dr. A. Rosenkranz and Prof. A. Klopstock that cases of atypical pneumonia in man, which have occurred in Israel, may have been caused by the virus of Psittacosis.

Leah Goldsmit
A. Komarov
Virus Diseases Laboratory, Haifa

BLUE TONGUE IN CATTLE AND SHEEP IN ISRAEL

In September 1950 a specific disease of cattle and sheep appeared in Israel which according to our informations was not observed before in cattle of this country. The epidemiology and the clinical symptoms were described by us elsewhere[1]. Further investigations were made at the Virus Research Laboratory, Haifa, and, the following results were obtained:

1. The causative agent of the disease has been isolated from the blood of infected sheep and grown in embryonated eggs. The experimental infection of cattle and sheep with the isolated virus gave rise to a disease which showed symptoms identical with those observed in the natural infection.

The virus was again recovered from the blood of experimentally infected cattle and sheep.

2. The virus was neutralized by the blood serum of naturally as well as experimentally infected and recovered cattle and sheep.

3. The optimum temperature for the growth of the virus in embryonated eggs was identical with that of the Blue Tongue Virus (i.e. 33.5° C).

4. Serial passages of the virus in embryonated eggs modified its virulence and the modified strain served for immunization purposes.

5. Baby mice were found susceptible to infection by the intra-cerebral route.

6. In co-operation with Dr. Haig of Onderstepoort, comparative experiments were carried out with the Israeli and African strains. The Israeli strain was found to be identical with Blue-Tongue virus, and cross-immunization experiments proved its antigenic relationship with the Jansen and Mimosa Park strains.

Leah Goldsmit
A. Komarov
Virus Diseases Laboratory, Haifa

REFERENCE

1. Goldsmit, L. and Komarov, A., 1951, *Refuah Veterinarith*, 8, 69, 100.

IMMUNIZATION OF CHICKEN WITH ATOMIZED LIVING NEWCASTLE DISEASE VIRUS VACCINE

Immunization of chicks by atomized living Newcastle virus was attempted and promising results were obtained. Under controlled laboratory conditions a very good immunity of chickens breathing suitable concentrations of live virus vaccine was reached. The solidity of this immunity could be demonstrated by

serological and challenge test a month after vaccination.

When the chicken was too young or/and the concentration of the virus vaccine too high, paralytic effects and death were observed; such was also the case in one attempted field immunization test in a flock of 280 30-day-old chickens.

It is concluded that immunization of chicken with a living Newcastle vaccine by the air route has great potentialities if properly controlled.

A. Kohn
Hebrew University—Hadassah Medical School, Jerusalem.

RESISTANCE FOR DRYING OF BACTERIOPHAGES OF *E. COLI* OF THE T GROUP

A study of the resistance of various phages to drying in the air revealed that there are significant differences in the behaviour of the phages of *E. coli* in the T group.

The sensitivity to drying of the phages in this group was found to be correlated to the size of phages particle and to serological groupings. The smallest phage, T1, is the most resistant one. The sensitivity increases with increasing dimensions of the phage particles, and the following gradient is found:

$$T1 < T5 < T3, \quad T7 < T2, T4, T6$$

the latest group being the most sensitive.

A. Kohn
Hebrew University—Hadassah Medical School, Jerusalem

THE HAEMAGGLUTININ OF *VIBRIO COMMA* AND ITS RELATION TO THE RECEPTOR DESTROYING ENZYME

Chu[1] observed that *Vibrio comma* filtrates contain a haemagglutinin as well as the receptor destroying enzyme, RDE, described by Burnet and Stone[2]. A more detailed examination of the phenomenon was undertaken to determine how closely it resembles the haemagglutinating factor of the dermotropic viruses and the enzyme/haemagglutinin system of the mumps-influenza group of viruses.

The erythrocytes of about half the fowls tested were found to be sensitive to this haemagglutinin. The RBC sensitive to the vibrio haemagglutinin were also agglutinated by vaccinia, ectromelia, crude trypsin and lipid extracts such as the Kahn antigen.

The haemagglutination reaction of *vibrio* is inhibited by materials known to inhibit influenza virus haemagglutination, e.g. normal plasma, ovarian cyst fluid and egg white. But, whereas, the plasma inhibitor to PR8 can be precipitated by half saturation with ammonium sulphate, no such separation of the inhibitor for vibrio haemagglutinin is achieved by this procedure.

The haemagglutinin and RDE are produced under the same conditions of growth of *V. comma*, and in general show a remarkable similarity of properties such as optimal condition of action, solubility and inactivation by heat and the trypsin-like enzyme present in filtrates of older cultures of *V. comma*. However, although the haemagglutinin like RDE is readily absorbed by all fowl erythrocytes ("sensitive" and "non-sensitive" to the vibrio haemagglutinin), it elutes more slowly. This, taken in conjunction with the fact that the haemagglutinin is produced in greater quantities than RDE in a strain of "water vibrio" as compared to the pathogenic Inaba and Ogawa strains of *V. comma*, indicates that despite their striking resemblance in properties the haemagglutinin and RDE are two distinct factors. It does not, of course, exclude the possibility of an interdependance of the two activities.

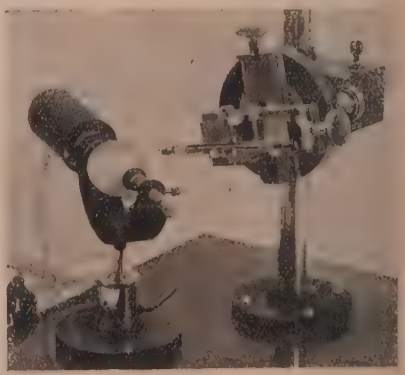
J. Mager
D. Aminoff
Weizmann Institute of Science, Rehovot.

REFERENCES

1. Chu, C. M., 1948, *J. Hygiene*, **46**, 42.
2. Burnet, F. M., and Stone, J. D., 1947, *Aust. J. Expt. Biol. and Med. Sc.*, **25**, 227.

A SYRINGE CARRIER AND EGG CLAMP FOR INTRAVENOUS INOCULATION OF THE CHICK-EMBRYO

To overcome the prohibitively high casualty rate resulting from "free-hand" injection and bleeding of the chick-embryo, an apparatus was



designed and built which consists of a rigid movable syringe carrier and an adjustable egg-clamp.

The device permits the accurate and precise placement of the hypodermic needle, at the proper angle, and entry into and removal from the blood vessel without erratic motion.

The apparatus allowed for successful serial bleedings. Detailed description with drawings is to be published elsewhere.

R. GOLOWASSER
M. C. SHELESNYAK
Weizmann Institute of Science, Rehovot.

Summaries of papers presented in the Section of General Microbiology and Chemotherapy

AN EFFECTIVE USE OF PETRI DISHES FOR MICRO CULTURES

The auxanogram of Beijerinck (1889) has been the basis for a cheap method for the characterization of bacteria and yeasts.

Our own experience with antibiotic producing micro-organisms, however, has shown that for several species grown on the same Petri dish, the diffusion of products of metabolism in the agar may confuse the results. It was therefore found necessary to grow each culture in such a way that there could be no contact between cultures.

The following procedure was developed with the use of sterile technique throughout. The substrate containing 1.5-2.0% agar, indicator, test materials, inhibitors or micro-organisms is pipetted into a Petri dish. The quantity used varies from 0.05-0.5 ml for each culture. The form may be circular or oval. By this means, 8-30 cultures may be grown in one Petri dish. The agar solidifies rapidly, permitting inversion of the Petri dish and pouring of agar plaques on the other side, so that the number of cultures is doubled.

Inoculation and incubation is generally similar to standard procedure, with adaptations to the conditions present.

Figure 1
A typical Petri dish

The following advantages are evident:

(a) Time, space, dishes and substrate material are saved.

(b) The agar solidifies immediately and inoculation can be made at once.

(c) The results are concentrated in a small area, easier for comparison and microscopic examination.

(d) Each plaque is distinct from its neighbour so that the results on one are not influenced by any other.

(e) The danger of air contamination is lessened (less nutrient area).

(f) The danger of condensation water dropping on to the agar is virtually eliminated.

The method is applicable to routine work and to preliminary research work.

A complete description of the work may be found in *J. Gen. Microbiology*.[2]

Figure 1 shows the appearance of a typical Petri dish.

RUHAMA TURNER-GRAFF
Dairy Research Laboratory, Agricultural Research Station, Rehovot.

REFERENCES

1. BEIJERINCK. M. W. 1889, *Arch. Nederland* 23, 367, cited from. Ernest Kuster, 1925, *Kultur der Mikroorganismen*, Leipzig, B. C. Teubner p. 97.
2 TURNER-GRAFF, R., 1952, *J. Gen. Microbiology*, 7, 112.

T. VAGINALIS IN THE STUDY OF RESISTANCE PROBLEMS

T. vaginalis is a suitable protozoan for the study of resistance since it can be grown easily in bacteria-free cultures and can be made resistant to a wide variety of compounds.

S. ADLER
A. BOCK
A. SADOVSKY
Hebrew University Hadassah Medical School, Jerusalem.

THE MODE OF ACTION OF CHLORAMPHENICOL

For the antibiotic chloramphenicol two points of attack have been suggested: interference with the utilisation of phenylalanine, or with the synthesis of tryptophan from anthranilic acid via indole. In a wild strain of *E. coli*, the inhibition caused by the antibiotic is reversed by tyrosine, phenylalanine, tryptophan and indole, but not by anthranilic acid. The synthesis of indole from anthranilic acid is thus the point of attack. This is confirmed by experiments with mutants of *E. coli*.

The source of the lacking carbon atom which completes the molecule of anthranilic acid to the indole ring, is methionine. In *E. coli*, wild type, the inhibition by chloramphenicol is reversed by the combination of anthranilic acid with methionine and vitamin B_{12}. Methionine has previously been found to be the source of the C_2 carbon atom of the purine nucleus and of the methyl group in nicotine.

Anthranilic acid is not the immediate precursor of indole; it is first converted into another substance the nature of which has not yet been elucidated.

ERNST D. BERGMANN
Scientific Department, Israeli Ministry of Defence, Tel-Aviv.

SARAH SICHER
Weizmann Institue of Science, Rehovot.

POPULATION CHANGES IN *BACTERIUM TULARENSE* AS REVEALED BY CHANGES IN SUSPENSION STABILITY

I. Mutual effect of agglutinable (S.A.) and non-agglutinable (N.S.A.) types

Since in *Bact. tularense* the properties of the surface of individual cells as revealed by the stability of the bacterial suspension are a better indicator of the main characters on which information is required than colonial morphology[1], an investigation of population dynamics was undertaken, based on changes occurring in agglutinability.

When serial transfers of N.S.A. type strains were made on G.C.B.A. slants, it was found that after approximately 35 transfers, the S.A. variants appeared, and afterwards their proportion in the population increased progressively. Experiments were carried out in which the original inoculation contained a mixture of the two types of micro-organisms in varying proportions, from 1:10^6 to 1:1. Every 24 hours, transfers to new slopes were made, and salt agglutination tests were performed. It was found that the addition of the S.A. type to the N.S.A. one effects decisively the population dynamics, and rapid establishment of the S.A. type occurred. It was shown that the S.A. type of micro-organisms exerts a strong inhibitory effect on the growth of the parent N.S.A. type. The effect was demonstrated by seeding strains of S.A. and N.S.A. types on G.C.B.A. plates placed close to each other. From the various combinations tested, only the strains of S.A. type had an inhibitory effect on the growth of the N.S.A. type strains.

II. The stability of *Bact. tularense* in the presence of electrolytes

Good correlation was found to exist in *B. tularense*, between virulence, and the agglutinability of strains by acid and acriflavine. An investigation of population dynamics in this micro-organism, based on detection of changes in suspension stability, was started by systematic investigations of the factors governing the phenomenon of agglutinability.

The effect of different electrolytes (NaCl, LiCl, KCl, KNO_3, K_2SO_4, K-acetate, K-citrate, $CaCl_2$, BaCl, $MgCl_2$) dyes (methylene-blue, acriflavine, eosin) and polyelectrolytes (heparin, polyaspartic-acid, polylysine, protamine) was tested on the stability of suspensions of virulent and avirulent strains. These strains were not influenced by any of the above reagents whilst avirulent strains showed practically complete agglutination by electrolytes, basic dyes and basic polyelectrolytes in certain ranges of concentration. The various types of reagents used for agglutination differ mainly in their effective concentration. Agglutination by N 160 NaCl served for quantitative determination of the proportion of salt agglutinable variants (S.A. type) and non-agglutinable variants (N.S.A. type) in mixed population.

These findings could be explained on the basis of interaction between surface polyelectrolytes and the electrolytes of the medium.

J. AVI-DOR H. YANIV
Hebrew University, Jerusalem

REFERENCE

1 EIGELSBACH, H. T., ERAUN, W. and HERRING, R. D., 1951. *J. Bact.*, 61, 557.

AN ANTIFUNGAL SUBSTANCE FROM *BACILLUS SUBTILIS*

In the course of work on cultures of *Penicillium roqueforti* which this laboratory prepares for the dairy industry, a contaminant was isolated which caused pronounced inhibition of the growth of the above mold. The organism exhibited the characteristics of *Bacillus subtilis* according to Bergey (1948).

Antagonism was observed between the

B. subtilis strain and *P. roqueforti* when grown on agar media in Petri dishes.

The isolated strain generally grew in the form of a pellicle on the liquid media. At times, however, growth within the broth was also observed. An investigation of this phenomenon showed that dissociation occurred. The regular form in this case was the R form in the pellicle which changed to the S form inside the broth.

For the production of the inhibitor, the medium of Walton and Woodruff[1] was used. This contained yeast extract, 10% sucrose, citric acid and inorganic salts. Optimum activity was obtained in shallow cultures incubated at 30° C for 6 days. The cell free culture fluid was active in dilutions up to 1:10. Determination of activity was made according to the method of Turner-Graff[2] with *P. roqueforti* as test organism.

The cell free culture fluid was extracted with n-butanol and the extract vacuum distilled almost to dryness. The brown viscous residue obtained was dissolved in a small volume of distilled water. If solution was not complete, a few drops of dilute NaOH were added. The inhibitor was precipitated from the above solution by addition of dilute HCl. The precipitate was washed with distilled water and dissolved in a small volume of ethyl alcohol. The resultant solution was treated with 4 volumes of ethyl ether and the precipitate obtained was finally dried in vacuo or at 105° C. Drying up to 10 hours at 105° C did not affect the activity of the inhibitor.

The product was active in concentrations down to 1:10000 against *P. roqueforti* and in slightly higher concentrations against *Aspergillus niger*. No inhibitory activity against several species of bacteria so far investigated was observed at these concentrations.

The inhibitor gave positive biuret, xanthoproteic and Millon reactions. It appears to be a non-dialysable acid polypeptide. Paper chromatography of an acid hydrolysate showed large quantities of glutamic and aspartic acids as well as serine, alanine, valine, lucine and phenylalanine. A colorimetric test for tyrosine was positive although it did not appear on the chromatogram.

Further work on the chemical and biological properties of the polypeptide is in progress. A detailed report will be published later.

J. Babad
A. Pinsky
R. Turner-Graff
N. Sharon
Dairy Research Laboratory, Agricultural Research Station, Rehovot.

REFERENCES

1. Walton and Woodruff 1949, *J. Clin. Invest.*, **28**, 924.
2. Turner-Graff, R. *This Journal*, **2**, 212.

DETERMINATION OF CO_2 FIXATION BY *WATER VIBRIO* WITH THE AID OF RADIOACTIVE CARBON

Water vibrio were found to multiply in distilled water buffered to pH 8 with Soerenson phosphate and containing the following (Baker's C.P.) chemicals: $CaCl_2$ 0.0025%, $FeSO_4$ 0.001%, $MgSO_4$ 0.02% and $(NH_4)_2SO_4$ 0.02%. After absorption of CO_2 from the air with KOH, growth was completely arrested. All experiments were carried out in the dark, thus excluding light as a factor in the fixation process.

The amount of CO_2 uptake by the *vibrio* was determined with the aid of radioactive carbon. A sample of the latter gave 2.5×10^7 counts/min/mg C. The closed system contained air in which the radioactive carbon was 0.5%. The total weight of the carbon in the bacteria was 0.5 mg representing 50% of the dry weight of the bacteria. Therefore, in the case of the fixation of all CO_2 available, our sample should give $(2.5 \times 10^7) (0.005) (0.5)$ or 6.2×10^4 counts/min. As we found only 300 counts /min, it seems that only 0.5% of the carbon came from the air.

Series of control experiments showed that neither dead bacteria nor the ingredients of the medium are able to absorb any radioactive carbon.

CO_2 is probably essential for the synthesis of some building stones, but it cannot be the sole carbon source for building up all the essential body constituents of the growing bacteria. Experiments as described above require a medium of *absolutely* pure ingredients since impurities even in minute amounts present in C.P. chemicals are sufficient to provide the carbon required for the limited growth of the organisms (10^5 bacteria/cc). We find that a contamination of 0.27% C, (i.e.9.7γ C cc introduced with the chemicals of the medium are sufficient to enable the above-mentioned bacterial growth, an amount of carbon undetectable by present chemical analytical methods.

I am indebted to Dr. I. Dostrovsky and Dr. F.S. Klein of the Weizmann Institute of Science, Rehovot, for allowing me to carry out the radioactive experiments and for their constant interest and advice.

Hanna Farkas
Department of Bacteriology, Hebrew University—Hadassah Medical School, Jerusalem.

SEWAGE PURIFICATION AND UTILIZATION

The removal of bacteria and parasites from sewage was studied during treatment of sewage at a high rate trickling filter pilot plant at Nahlat Ahim, Jerusalem.

The plant comprises a primary settling tank, biological filters and a secondary settling tank.

The coliform count was as high as $16x10^7$ organisms per ml of raw sewage. A series of tests on the progress of purification showed that the diminution in the number of coliform organisms was between 70 and 90 percent.

There was also a considerable decrease in the number of intestinal parasites. However their numbers in filter effluent are such as to make further treatment necessary.

A study was made of the changes in the number of coliform organisms in experimental sewage-irrigated plots under maize. The tests were carried out during the summer season at various depths of soil. The M.P.N. at the surface decreased from $2.4x10^6$ to 240 organisms during 10 days. Results for plots irrigated with raw sewage and effluent were very similar.

During the winter a study was made of changes in the numbers of coliforms and *Salmonella tennessee* in an uncultivated plot, which had been irrigated with raw sewage. The course of the diminution in numbers of both varieties was roughly parallel. The diminution of *Salm. tennessee* was greater than that of the coliforms but not very much so. Eight weeks after the beginning of the experiment the number of both groups was still considerable.

The present investigation has been carried out in conjunction with the Sanitation Division of the Israel Ministry of Health.

SONYA BERGNER-RABINOWITZ
Sewage Research Laboratory
Government Central Laboratories
Israel Ministry of Health,
Jerusalem

PROBLEMS OF DIMORPHISM OF DERMATOPHYTES

The number of positive microscopical examinations for fungi in human skin, hair and nails is greater than the number of positive cultures obtained on routine media.

A series of routine inoculations of material taken from patients was made on plain Sabouraud maltose agar (Sab) and simultaneously on the same medium containing 50 units/ml streptomycin and 5 units/ml pencillin (SabSP). From 277 samples of mycotic and non-mycotic skin disease, inocula were made at the same time on both media, and the cultures were incubated at 26C°. On SabSP, growth of pathogenic fungi appeared in about twice as many instances as on Sab. Part of this increase could be ascribed to the fact that bacterial contaminants growing on the slants interfered with the slow-growing fungus and were inhibited by the antibiotics. In a number of cultures where growth appeared without bacterial contaminations, the growths started earlier on SabSP, and the development of the colonies proceeded at a faster rate than on Sab, making identification possible at an earlier date. In order to investigate this enhancing effect of the drugs in detail varying amounts of penicillin were added to Petri dishes containg 20 ml Sab in concentrations from 2 to 100 u/ml. To other plates, streptomycin was added in concentrations from 5 to 1000 u/ml. Plates without addition served as controls. In the center of each plate, small equal pieces of growth from stock cultures of four dermatophytes, namely *T. mentagrophytes*, *T. rubrum*, *T. violaceum* and *T. schoenleini* were planted, the plates incubated in inversed position at 26°C and the diameter of the developing colonies measured every three days over a four-week period. No differences in size or morphology could be detected between the different plates.

An explanation of these apparently contradictory results is attempted below. It was shown by Georg and Fowle[1] that for certain organisms, some accessory factors of the B group had to be added to the artificial medium for growth upon primary isolation. Several of the antibiotics contain vitamin B_{12} or animal protein factor (APF) which might constitute the requirements of some fungi and explain the effect of the antibiotics. But since it is known that peptones used in commercial media contain sufficient amounts of vitamins especially of the B group to cover the requirements of these organisms, this explanation does not seem to be valid.

It is known that pathogenic fungi appear in lesions as hyphae and arthrospores only, whereas on artificial media the growth is composed of submerged and aerial hyphae, the latter bearing the various reproductive structures making identification possible. According to Nickerson[2], the morphologically incomplete form of the dermatophytes in the lesions is conditioned by an unknown substance secreted by the cells of the host tissue inhibiting the full development of the fungi. This inhibition may be due to an antagonistic micro-organism of the endogenous flora of the skin. When scales containing these bacteria are planted on a medium, they continue to produce a substance which inhibits the development of a fungus colony. In the presence of suitable antibiotics their inhibitory effect is eliminated and the fungus colony develops more quickly. On subsequent transfers the same organisms grow much faster on plain media than on primary isolation. Most of the inhibiting bacteria usually will not grow on common laboratory media and especially not on acid ones like Sab, but several strains of *B. subtilis* isolated from human skin have been shown to inhibit at least temporarily the growth of various dermatophytes.

It may be assumed that two morphologically

different phases of the same fungus have different nutritional requirements. It seems that in the primary isolation on artificial media, the organism requires some unknown substance in order to facilitate its change from parasitic to saprophytic life. In hitherto unpublished experiments conducted together with Dr. Nickerson, it was shown that *T. mentagrophytes* could be grown in shake cultures in a medium containing small amounts of yeast extract and salts without further addition of a carbon or nitrogen source. In this medium the dermatophytes grow as small round balls which consist of hyphae and arthrospores only, as in lesions during parasitic life. In experiments now being conducted with *T.violaceum* and *T. schoenleini*, gradual loss of proteolytic enzymatic activity on repeated transfers could be shown. These facts indicate that in the absence of unknown accessory factors, certain enzyme systems are not activated. Whether a fungus grows on primary isolation or not depends upon its ablility to activate enzyme systems necessary for saprophytic life. Thus the action of the antibiotics would consist of either activation of enzyme systems essential for saprophytic life or at least in changing the substrate affinity of enzyme systems active during the parasitic phase of life.

F. RAUBITSCHEK
Department of Dermatology, Hadassah Hospital, Jerusalem.

REFERENCES

1. GEORG, L. K. and FOWLE, L. P., 1947, *Archives Derm. Syph.*, 56, 780.
2. NICKERSON, W. J., 1947, *Biology of Pathogenic Fungi.* Waltham, Mass.

NEWS AND VIEWS

ISRAEL MICROBIOLOGICAL SOCIETY

The 9th meeting of the Israel Microbiological Society took place in Jerusalem between the 10th and 12th of March, 1952. Of the 60 papers read at the meeting, 14 dealt with virology; 13 papers were devoted to general bacteriology and bacterial metabolism, 6 to parasitology, 8 to clinical bacteriology and methods, 6 to immunology, 6 to enteric infections and 7 to the problem of virulence. The most important results from the practical point of view were: the discovery of the causative agent of *Psittacosis* in Israel, carries by pigeons (A. Komarov and L. Goldsmit); the identification of organisms of the pleuropneumonia group in man in Israel (W. Hirsch); the finding of a new virus in Israel similar to the West Nile virus and the discovery of *Coxsackie* viruses (H. Bernkopf); the modification of street virus from a dog by prolonged passages through embryonated eggs (A. Komarov and K. Hornstein).

Prof. A. L. Olitizki was elected President of the Society, and Dr. N. Grossowitz and Dr. J. Gurevitz were elected members of the Central Committee.

In order to assure the continuity of the work of the Society in the period between General Meetings, Mr. D. Hermoni, Dr. A. Komarov, and Dr. Keanan were entrusted with the task of organizing local boards in Jerusalem, Haifa, Rehovot and Tel Aviv respectively.

The four local secretaries will be members of the Central Committee.

ISRAEL BOTANICAL SOCIETY

The 42nd meeting of the Israel Botanical Society was held in Jerusalem, on July 22 and 23, 1952. The programme included the following lectures: Dr. Poliakoff-Mayber: "Germination Inhibitors and the Activity of Catalase in Germinating Seeds", Prof. J. Reichert: "The Lichen *Lecanora esculenta* and its Biogeography", Dr. A. Mayer: "Experiments on the Growth of *Chlorella*", Mrs. Katz: "Experiments on the Action of Antibiotics on Phytopathogenic Fungi". Dr. D. Zaitschek, in his lecture on "Seeds of Prehistoric Cultivated Plants Excavated in Palestine" complained of the lack of attention paid to this subject by some archaeologists. Mr. Galil, in his lecture on "The Physiological Depth of Geophytes" described experiments conducted by him to elucidate the factors which determine the depth of the bulb of *Leopoldia maritima*.

A special session was devoted to the banana. Experiments with this crop carried out by the Research Committee of the Jordan Valley settlements were described in the following lectures: Mr. S. Stoler: "The Life-Cycle of the Banana", Dr. E. Shmueli: "Responses of the Banana Plant to Variations of Soil Moisture", Mr. D. Siev: "Factors Interfering with the Normal Development of the Banana".

A joint discussion with the Israel Zoological Society was devoted to the Irano-Turanian region. It included the following lectures: Prof. M. Zohary: "The Irano-Turanian Region and its Western Limit", Dr. N. Feinbrun: "The Irano-Turanian Territories of the Negev", Prof. G. Haas: "The Zoogeography of Reptiles", Mr. J. Wahrman: "Ecological Units of the Fauna of the Negev". The ensuing discussion was mainly concerned with the question of the extent to which physiogeographical divisions might serve as a basis for the determination of zoogeographical units.

A report was submitted by the outgoing committee. Various speakers expressed concern over the ever-increasing destruction of some of the most impressive and important natural habitats. There is urgent need for the establishment by the government of plant and animal reservations in order to prevent the extinction of rare species. The new committee was instructed to foster the recognition of this important problem by the government and the public. Prof. J. Reichert was elected Chairman for the next year.

RENE NEUVILLE

On July 7, 1952, the Geological Association of Israel met to commemorate the death of the noted prehistorian, René Neuville, French Minister Plenipotentiary and Consul-General in Israel.

Dr. Ben Tor opened the meeting with a moving tribute to the deceased and Dr. N. Shalem reviewed the life and work of the great diplomat and scientist. As diplomat, M. Neuville was Doyen of the Consular Corps in Israel and Jordan and recorded his experiences in a book entitled *Heurs et Malheurs des Consuls de France à Jerusalem*. Side by side with his official duties he pursued his investigations into the

prehistory of Palestine. He carried out excavations, organized research projects and published his findings. His most importamt work, *Le Paleolithique et le Misolitique du Desert de Judee* was completed and published just before his death. For this outstanding work, he received the Bordin award of the *Academie des Inscriptions et Belles Lettres*. His latest book may be compared with the famous work of Garrod and Bates on the Carmel caves and is indeed a work of exceptional merit.

René Neuville participated actively in the scientific life of Palestine. He was chairman of the Palestine Oriental Society, member of the Mandatory Archaelogical Committee, scientific correspondent of *Institut de Paleontologie Humaine*, and general delegate for the Near East to *Societé Prehistorique de France*. In 1942 he was awarded the Moroccan prize and was honoured with the title *Laureat de l'Institut de France*.

With his death France lost one of her great sons and Israel one of her most loyal friends.

The tributes were followed by Prof. Picard's lecture *The Pleistocene Peat of Lake Hula*, which appears in full in this issue.

ISRAEL ZOOLOGICAL SOCIETY

The half-yearly meeting of the Israel Zoological Society in Jerusalem on 21-22 July, 1952, was devoted chiefly to a symposium on problems of zoogeography. Prof. Haas discussed the distribution of reptiles throughout the world, basing his discussion mainly on historical evidence. Dr. Bytinsky-Salz analysed the composition of the ant population of Eastern Mediterranean countries, and Prof. Theodor gave an analysis of the zoogeography of some groups of *Diptera* in the Middle East, stressing the importance of an intimate knowledge of the ecology of the insects concerned.

A joint session of the Botanical and Zoological Societies discussed problems of interest to both. The main question was, to what extent the phytogeographic system developed by Eig was applicable to animals and in this connection much attention was paid to the definition and value of one of the most controversial features of Eig's system, the so-called Irano-Turanian region. Prof. Zohari gave a review on the development and definition of this conception and showed that recent research, mainly in Russia, had moved far from the original definition. The old Irano-Turanian region, as commonly understood, has been subdivided into two main units, a Central Asian and a Western Asian part. He considered the Irano-Turanian territory of Israel as rather transitional between the western part of the Irano-Turanian region and the Mediterranean territory and thought that it showed more affinities to the Mauretanian subregion than to the Western Asian part of the Irano-Turanian region. Dr. Feinbrun analysed the Irano-Turanian territories in the Negev on the basis of a detailed study of the plant communities and the edaphic, orographic and climatic conditions in the area, restricting her analysis to the purely ecologic aspect and refraining from historic interpretation. Prof. Haas analysed the reptile fauna of the Middle East, basing his discussion mainly on historical evidence, without which, in his opinion, it is impossible to arrive at an understanding of the often puzzling conditions. Mr. Wahrmann gave a detailed zoogeographical analysis of various groups of animals in the Negev, basing it on the conception of an "ecofauna" as evolved by Uvarov.

In the discussion it was stressed that the method of recording geographical distribution on a map, based on data from the literature, is insufficient and apt to give misleading results. Previous attempts to arrive at general results have been premature, as the necessary data have not been available. A zoogeographical analysis should only be attempted by a student of a particular group, who has a thorough knowledge of the systematics and the ecology of this group, basing it on actual study in the field. As far as possible, historic evidence in addition to the ecological, systematic and geographical data should be used. Such knowledge does not yet exist for many groups of animals and the collection of this knowledge should therefore precede zoogeographical analysis. The discussion brought out clearly that the analysis of a fauna should proceed in two steps. An ecological analysis should form the basis for a later analysis of the geographical and historical aspects. It was pointed out that the terminology of phytogeography lent itself to historical interpretation, thereby prejudicing unbiased study. Several speakers stressed the lack or scarcity of elements of Irano-Turanian origin in Israel in the groups studied by them and the fact that the distribution of such elements did not at all coincide with the Irano-Turanian territories as defined by plant communities.

In addition to the symposium, a session was devoted to a review of recent research on symbiosis by Dr. Aschner and to a review of recent research on the life cycle of malaria parasites by Dr. Zuckerman. Dr. Swirsky gave a report on his work on the biology of various species of aphids in Israel.

THE ISRAEL SOCIETY FOR GEODESY AND GEOPHYSICS

The first annual meeting of the Society since its foundation in November 1950, took place on the 20th of July, 1952. The Society forms the link between persons interested in the field of geophysical sciences and geodesy in Israel and

abroad, and especially with the International Union of Geodesy and Geophysics (U.I.G.G.), which is a member of the "International Council of Scientific Unions" of Unesco. The Society consists of seven sections, which represent the following sciences: Geodesy, Seismology and Physics of the Earth's Interior, Meterology, Terrestrial Magnetism and Electricity, Physical Oceanography, Vulcanology, and Scientific Hydrology.

The main task of the annual meeting was the rendering of the report on the Society's activities during the year and a half since its establishment. The reports of the chairman of the Society, Mr. M. Goldschmidt, and the heads of the sections surveyed the development of the Society, the organisation of the sections, their activities, and the connection with U.I.G.G. The Society has 53 members at present, the majority of whom belongs to the "major" sections: Geodesy, Meterology and Hydrology. Meetings of the sections dealt with technical problems and included the reading of scientific papers; a symposium on the aspects of the floods of December 1951 for Meterology, Hydrology and Soil Conservation are being held in September 1952 as a joint session of the Meteorological and Hydrological sections.

The financial report reflected the Society's first steps of development, and the difficulties encountered in trying to fulfil the obligations of Israel towards international organisations. — The Society's library, which consists mainly of the publications of U.I.G.G. and its seven associations, is developing slowly. Proposals were made on the subject of bibliopraphical activities within the framework of the sciences represented by the Society. — An audit commission was elected consisting of two members: Dr. N. Shalem and Mr. J. Lorch.

NOTICE TO CONTRIBUTORS (cont'd)

References

References are to be cited in the text by numbers, e.g., Taylor[3], and are to be arranged in the order in which they appear in the text. The following form should be used:

3. TAYLOR, G. I., 1932, *Proc. R. Soc.* London, **A138**, 41.

Book references should be prepared according to the following order:

4. JACKSON, F., 1930, *Thermodynamics*,4th ed., Wiley, New York.

The title of a paper will appear in the references only if it has been published solely in a local Hebrew journal. This is printed in regular type and is indicated by double inverted commas. Only those references should be indicated which are used in the text.

Special consideration is given a bibliography of particular importance. This will appear in full (with titles) and will contain also references not mentioned in the text.

TYPOGRAPHY

In all matters of typography the form adopted in this issue should be followed. Particular attention should be given position (of symbols, headings, etc.) and type specification.

ILLUSTRATIONS

Illustrations should be sent in a state suitable for direct photographic reproduction. Line drawngis should be drawn in large scale with India ink on white drawing paper, bristol board, tracing paper, blue linen, or blue-lined graph paper. If the lettering cannot be drawn neatly, indicate in pencil for the guidance of the draftsman. Possible photographic reduction of a drawing should be carefully considered when lettering and in other details.

Half tone photographs should be on glossy contrast paper.

Illustrations should be mounted on separate sheets of paper on which the caption and figure number is typed. Each drawing and photograph should be identified on the back with the author's name and figure number.

The place the figure is to appear should be indicated in the margin of the MS.

PROOFS

Authors making revisions in proofs will be required to bear the costs thereof. Proofs should be returned *immediately* to the Editor.

REPRINTS

Each author will receive 25 reprints free of charge, and additional reprints up to a maximum of 100, may be received at nominal cost. Reprints must be ordered at the time the first proof is returned.

ABSTRACTS

Each contribution (article or letter), should be accompanied by an informative abstract not exceeding about 3% of the total length of the paper, in triplicate.

Manuscripts should be addressed:
Executive Editor
Bulletin of the Research Council of Israel
P.O.B. 607, Jerusalem

Annual Subscription (four numbers): IL.4.000 ($5.50) post free. Orders in Europe should be addressed to North Holland Publishing Co., Amsterdam C, and in America to Interscience Publishers Inc. New York, N.Y., directly or through booksellers.

Single copy IL.1.000. ($ 1.50)

Bulletin of the Research Council of Israel.
Published by the Government Printer for the Research Council of Israel.
Printed by Government Press, Jerusalem.